به نام خدا
دانشگاه تهران
پردیس دانشکده‌های فنی
دانشکده مهندسی برق و کامپیوتر

سیگنال ها و سیستم ها

استاد: دکتر سعید اخوان

گزارش تمرین کامپیوتری 1

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نیمسال دوم 1399 – 1400

فهرست گزارش سؤالات

سوال 1

```
function [mydet] = p1(X)
[row,column] = size(X);
if row == column
    mydet = 0;
    if row == 2
        mydet = X(1)*X(4)-X(2)*X(3);
    else
        for i = 1:row
            l = X(1,i)*(-1)^(i+1);
            m = X;
            m(1,:) = [];
            m(:,i) = [];
            mydet = mydet + l*p1(m);
        end
    end
else
    disp("!!! Please enter n*n matrix.");
end
```

سوال 2

```
function [myinv] = p2(X)
[row,column] = size(X);
if p1(X) ~= 0
    if row == column
        myinv = zeros(row);
        if row == 2
            myinv = 1/p1(X) * [X(4) -X(3); -X(2) X(1)];
        else
            for i = 1:row
                for j = 1:row
                    k = X;
                    k(j,:) = [];
                    k(:,i) = [];
                    myinv(j,i) = p1(k)*(-1)^(i+j);
                end
            end
            myinv = 1/p1(X) * (myinv.');
        end
    else
        disp("!!! Please enter n*n matrix.");
    end
else
    disp("!!! The matrix is not invertible.");
end
```

سوال 3

$x[n] = [2, -2, 7, -3, 2, 4, -6, 1] \quad ; 1 \leq n \leq 8$

$h[n] = [5, 2, 4, -6, 5, 1, -8, 0, 7, 2, 9] \quad ; 1 \leq n \leq 11$

$$(x * h)[n] = \sum_{m=-\infty}^{+\infty} x[n-m]\, h[m]$$

$x[n-m] \Rightarrow$ 1, -6, 4, 2, -3, 7, -2, 2 ⟶ (حرکت می‌کند)

n-8 ... n-3 n-2 n-1

5, 2, 4, -6, 5, 1, -8, 0, 7, 2, 9

1 2 3 ... 11

$\Rightarrow \quad n < 2 \longrightarrow x*h[n] = 0$

$n = 2 \longrightarrow x*h[2] = 10$

$n = 3 \longrightarrow x*h[3] = -2\times5 + 2\times2 = -10 + 4 = -6$

$n = 4 \longrightarrow x*h[4] = 7\times5 - 2\times2 + 2\times4 = 35 - 4 + 8 = 39$

$n = 5 \longrightarrow x*h[5] = -3\times5 + 7\times2 - 2\times4 + 2\times(-6) = -15 + 14 - 8 - 12 = -21$

$n = 6: \quad x*h[6] = 2\times5 - 3\times2 + 7\times4 - 2\times(-6) + 2\times5 = 10 - 6 + 28 + 12 + 10 = 54$

$n = 7: \quad x*h[7] = 4\times5 + 2\times2 - 3\times4 + 7\times(-6) - 2\times5 + 2\times1 = -38$

$x*h[8] = -6\times5 + 4\times2 + 2\times4 - 3\times(-6) + 7\times5 - 2\times1 + 2\times(-8) = 21$

$x*h[9] = 1\times5 - 6\times2 + 4\times4 + 2\times(-6) - 3\times5 + 7\times1 - 2\times(-8) + 2\times(0) = 5$

$x*h[10] = 1\times2 - 6\times4 + 4\times(-6) + 2\times5 - 3\times1 + 7\times(-8) - 2\times(0) + 2\times7 = -81$

$x*h[11] = 1\times4 - 6\times(-6) + 4\times5 + 2\times1 - 3\times(-8) + 7\times(0) - 2\times7 + 2\times2 = 76$

$x*h[12] = 1\times(-6) - 6\times5 + 4\times1 + 2\times(-8) - 3(0) + 7\times7 - 2\times2 + 2\times9 = 15$

$x*h[13] = 1\times5 - 6\times1 + 4\times(-8) + 2\times(0) - 3\times7 + 7\times2 - 2\times9 =$

$x*h[14] = 1\times1 - 6\times(-8) + 4\times(0) + 2\times7 - 3\times2 + 7\times9 =$

$x * h[15] = 1\times(-8) - 6\times(0) + 4\times 7 + 2\times 2 - 3\times 9 = -3$

$x * h[16] = 1\times(0) - 6\times 7 + 4\times 2 + 2\times 9 = -42 + 8 + 18 = -16$

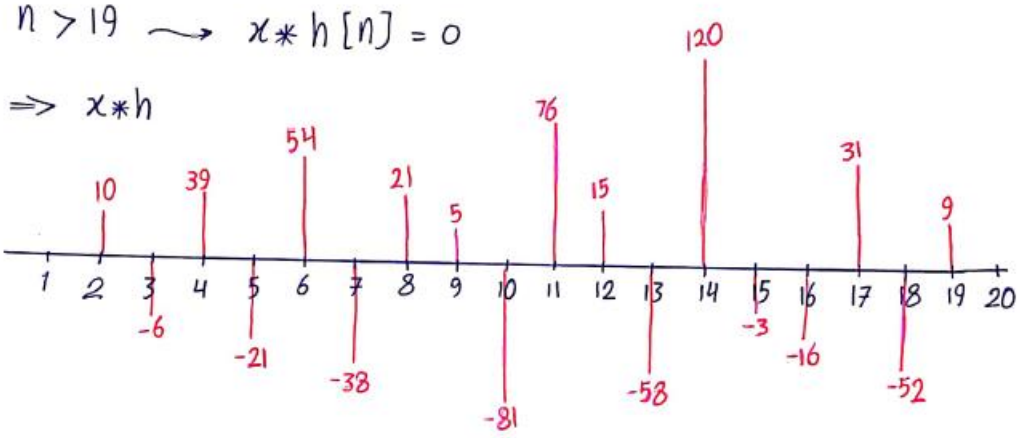
$x * h[17] = 1\times 7 - 6\times 2 + 4\times 9 = 7 - 12 + 36 = 31$

$x * h[18] = 1\times 2 - 6\times 9 = 2 - 54 = -52$

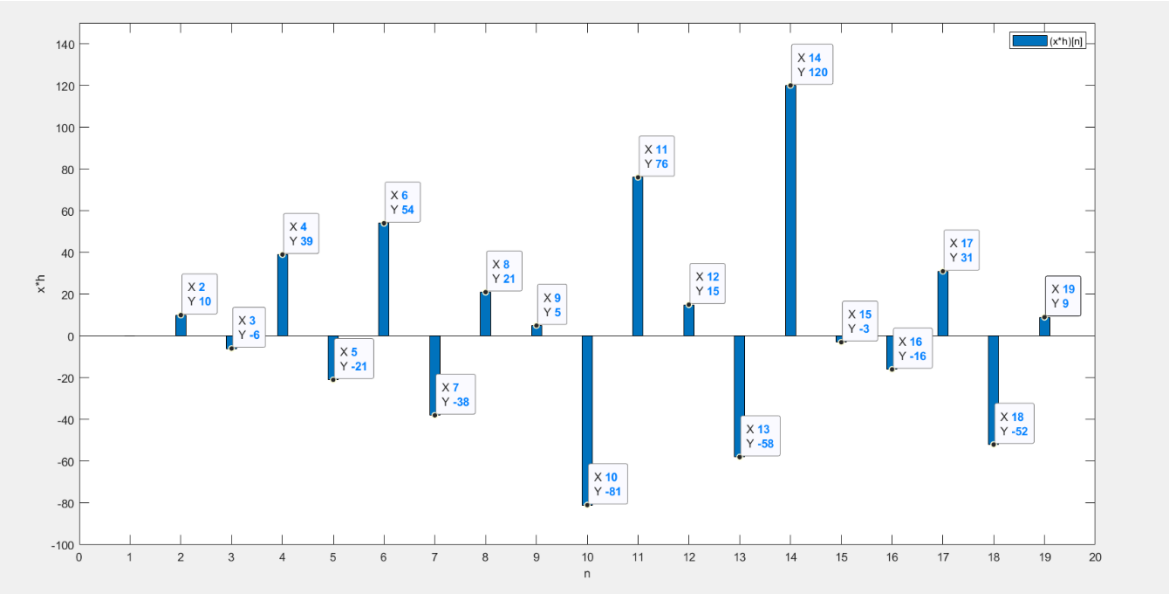
$x * h[19] = 1\times 9 = 9$

$n > 19 \rightsquigarrow x * h[n] = 0$

$\Rightarrow x * h$



```
%Question3:
clear; close all; clc;
x = [2 -2 7 -3 2 4 -6 1];
h = [5 2 4 -6 5 1 -8 0 7 2 9];
result = [zeros(1,1) conv(x,h)];
bar(result,0.2);
set(gca,'xtick', 0 : 1 : 20, 'xlim', [0,20])
set(gca,'ytick', -100 : 20 : 150, 'ylim', [-100,150])
xlabel("n");
ylabel("x*h");
legend("(x*h)[n]");
```

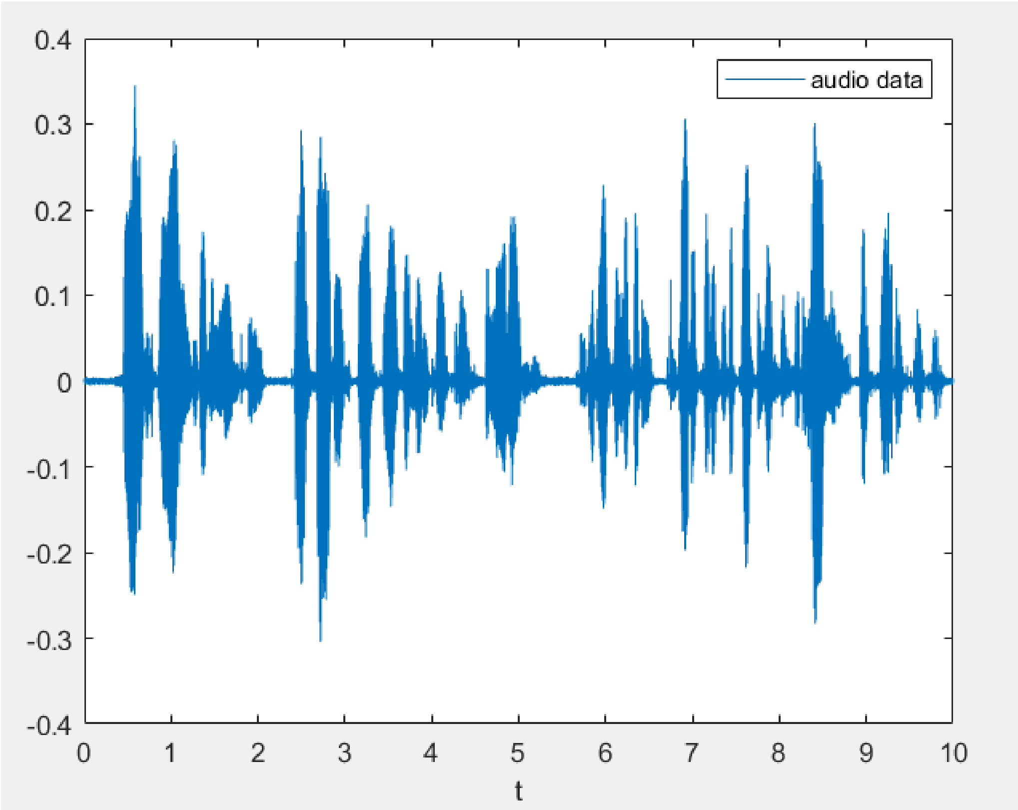


سوال 4

```
%Question4:=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=
clear; close all; clc;
[x,Fs] = audioread("gettysburg10.wav");
fprintf("==> Fs: Sampling Frequency = %d\n",Fs);

==> Fs: Sampling Frequency = 22050


%Question4_1:=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=
[b,~] = size(x);
t = linspace(0,10,b);
plot(t,x);
xlabel("t");
legend("audio data");
%sound(x,Fs);
%pause(10);
```



سؤال 24-: $y[n] = x[n] + a\,x[n-n_0]$

اثبات LTI بودن : اثبات L بودن & اثبات TI بودن $\Rightarrow \begin{cases} \alpha x_1[n] + \alpha a x_1[n-n_0] \\ \beta x_2[n] + \beta a x_2[n-n_0] \end{cases} \xrightarrow{\oplus} z[n]$

$W = \alpha\left(x_1[n] + a x_1[n-n_0]\right) + \beta\left(x_2[n] + a x_2[n-n_0]\right) = \alpha y_1[n] + \beta y_2[n]$ خطی ✓

$z = x[n-n_s] \longrightarrow w = x[n-n_s] + a\,x[n-n_0-n_s] = y[n-n_s]$ تغییرناپذیر با زمان ✓

پاسخ ضربه برابر است با : $h[n] = \delta[n] + a\,\delta[n-n_0]$

```
%Question4_3:==========================================
n0 = 1*Fs;  % 1sec echo
a = 0.81;   % power of echo = 81%
y1 = x;
for n = 1:b
    if n > n0
        y1(n) = x(n) + a*x(n - n0);
    end
end
%sound(y1,Fs);
%pause(10);
audiowrite("y1.wav",y1,Fs);
```

```
%Question4_4:==========================================
n0 = 0.4*Fs;
a = 0.1;
y_best = x;
for n = 1:b
    if n > n0
        y_best(n) = x(n) + a*x(n - n0);
    end
end
%sound(y_best,Fs);
%pause(10);
audiowrite("y_best.wav",y_best,Fs);
```

سؤال 4_5 :

$$y[n] = x[n] + a\,x[n-n_0] \quad *$$

y ↓ ✓ x ↓ ✓ a ↓ ? n_0 ↓ ?

از آنجا که ماکزیمم همبستگی زمانی رخ می‌دهد که دو سیگنال یکسان باشند می‌توان گفت مقدار شیفت همان ماکزیمم همبستگی است. یعنی:

$$n_0 = \max\{R_{xy}\}$$

با استفاده از سیستم $y[n] = x[n-n_0]$ ، خروجی y_2 را بدست می‌آوریم.

y_3 را با استفاده از رابطه * و به شکل روبرو تعریف می‌کنیم:

$$y_3 = y[n] - x[n] = a\,x[n-n_0]$$

با توجه به y_2 و y_3 مقدار a قابل محاسبه است:

$$a = \max\{y_3\} / \max\{y_2\}$$

```
%Question4_5:==========================================
[x_test,Fs_test] = audioread("x_test.wav");
[y_test,~] = audioread("y_test.wav");
[b,~] = size(x_test);
r = xcorr(x_test,y_test);
n0 = int16(max(r)); % <==
y_test2 = x_test;
for n = 1:b
    if n > n0
        y_test2(n) = x_test(n - n0);     % only shift values
    end
end
y_test3 = y_test(1:b,1);     % length y_test3 = x_test
y_test3 = y_test3 - x_test; % y_test3 = a*x_test(n - n0)
a = (max(y_test3)/max(y_test2));    % <==
fprintf("n0 = %d\na = %f\n", n0, a);
% sound(y_test,Fs_test);
% pause(10);
% sound(y_test2,Fs_test);
% pause(10);
% sound(y_test3,Fs_test);
% pause(10);
y_test4 = x_test;
for n = 1:b
    if n > n0
        y_test4(n) = x_test(n) + a*x_test(n - n0);     % only shift
values
    end
end
% sound(y_test4,Fs_test);
% pause(10);
```