Name: Thong Thach

SID:862224662

UCR net ID: tthac005@ucr.edu

Session: 022, Thursday 2-4:50

1)

Assume that the system between the voice $x[n]$ from your mouth and the acoustic signal $y[n]$ picked up by a microphone is linear and time-invariant, and hence

$$y[n] = h[n] * x[n] = \sum_{l=1}^{L} h[l]x[n-l]. \quad (1)$$

To see the effect of the echo distortion, assume

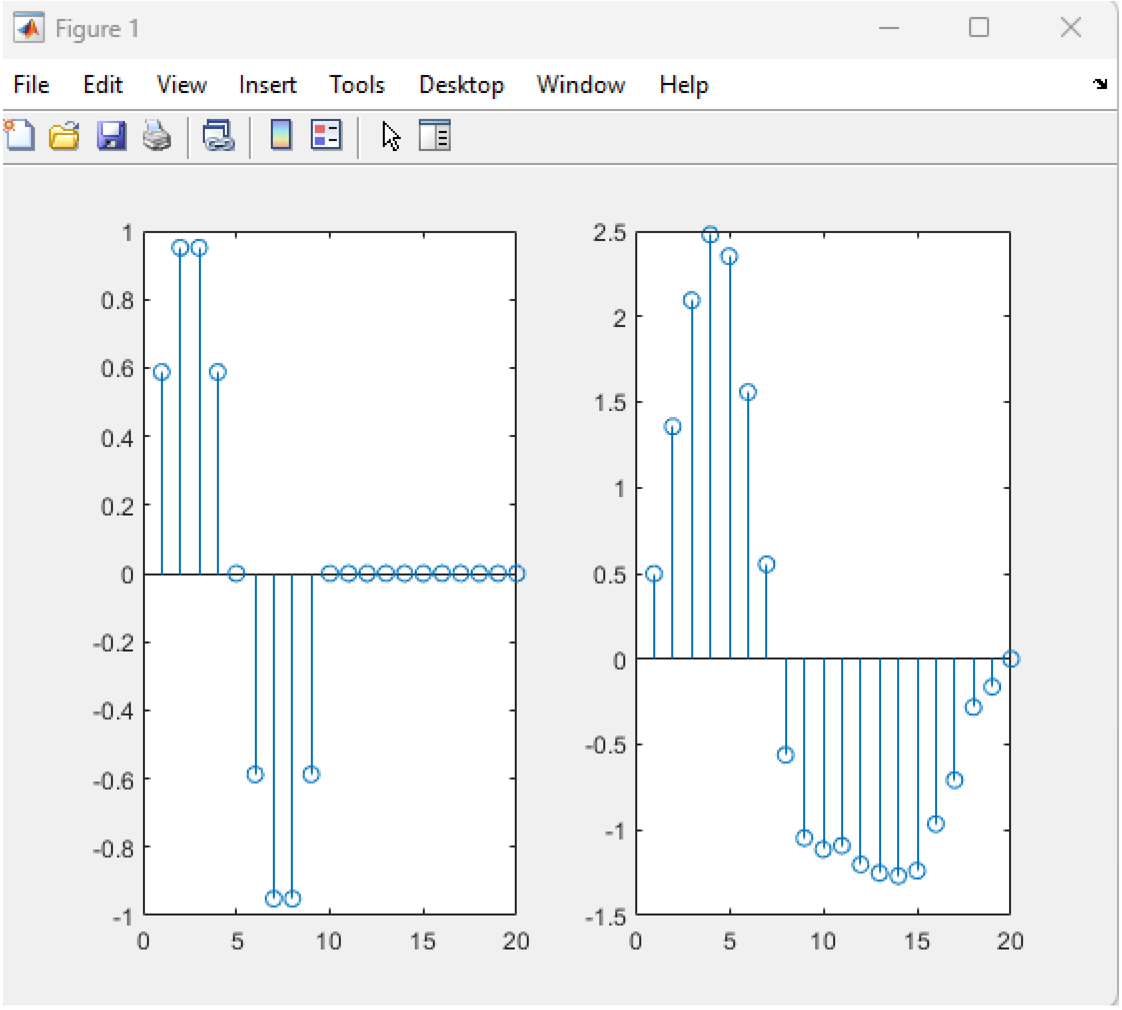
$$x[n] = \sin(\frac{\pi}{5}n)(u[n] - u[n-10]) \quad (2)$$

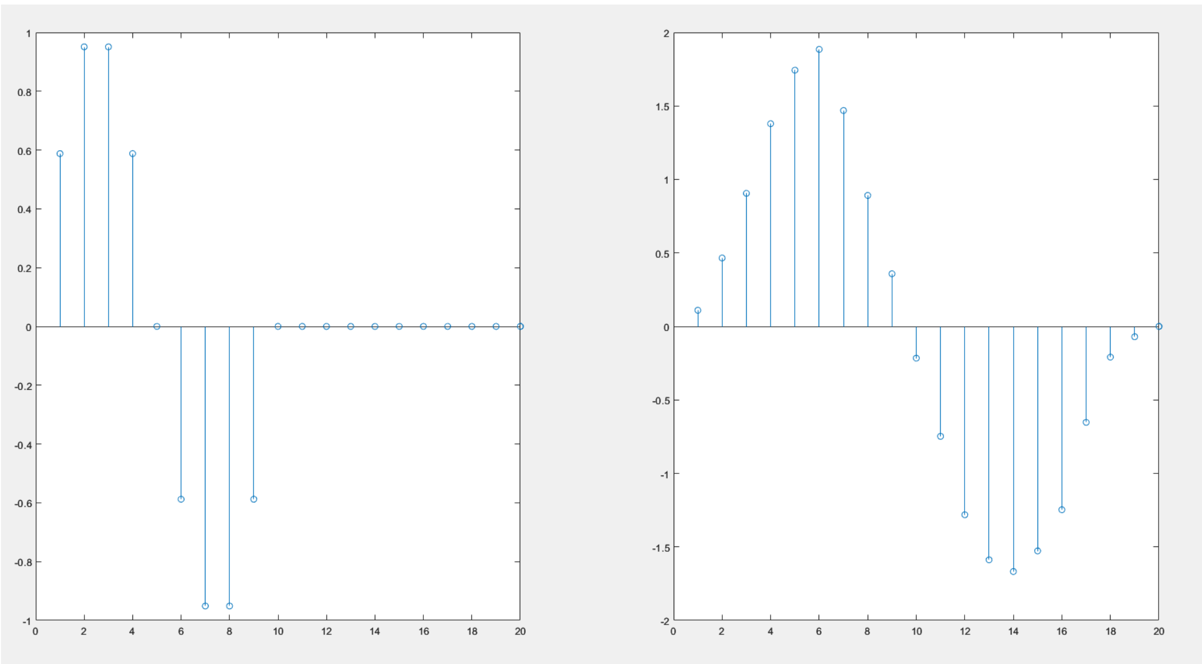
and also choose the echo coefficients $h[l]$ for all $0 \leq l \leq 10$ randomly. Here $L = 10$. Plot $x[n]$ and $y[n]$ for $0 \leq n \leq 20$. Discuss the impact of $h[n]$ on $y[n]$ in relation to $x[n]$.

For the coding part:

```
n=1:10;
x=sin(pi/5 * n);
x=[x,zeros(1,10)];
h=rand(1,11);
y=conv(x,h);
figure(1);
subplot(121);
stem(x(1:20));
subplot(122);
stem(y(1:20));
```

For the plot:





Discuss the impact of h[n] on y[n] in relation to x[n]:

The impact of h[n] on y[n] in relation to x[n] is h[n] created the noise on x[n] original signal pulse, which makes the y[n] signal pulses are the distortion from x[n] signal pulses. The distortion effects deform the signal of the original waveform. It first appears that the waveform shifted up after a few first signal pulses relative to the beginning of the start pulse; after that, the original position signal pulses have been dropped to -0.9, but the signal pulses after distortion have oscillated between the range -0.5 to -1.5. Finally, the original signal pulses have been shifted down from 0 to negative values on the y-axis. A lot of noises have interrupted the original signal pulses. That's distortion effects on h[n].

2)

Assume the same $x[n]$ in (2) but $h[n] = 0.98^n u[n]$ which is the impulse response of a first-order feedback system.

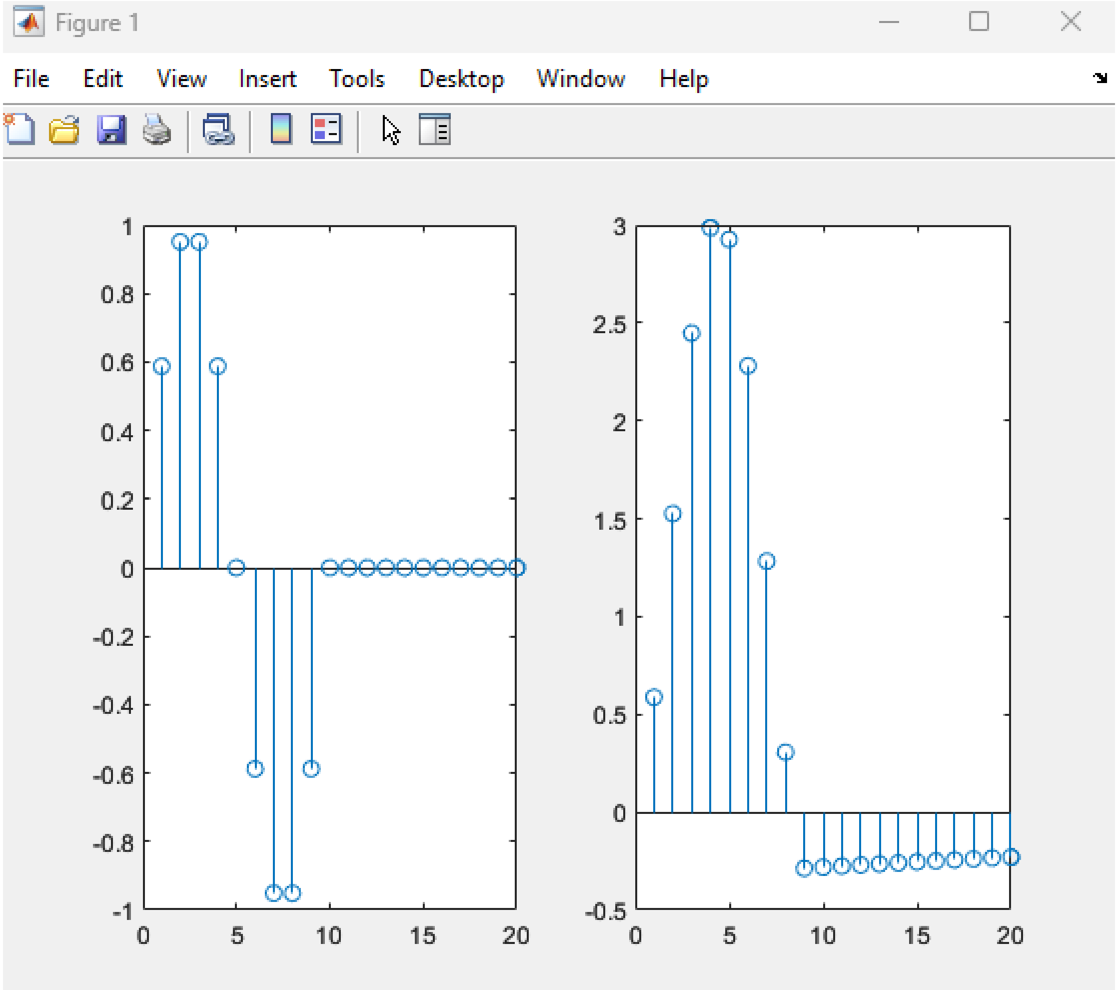
a) Compute and plot $y[n] = x[n] * h[n]$ for $0 \leq n \leq 20$ (with a large L such that $h[L]$ is negligible). Discuss the distortion effect by $h[n]$.

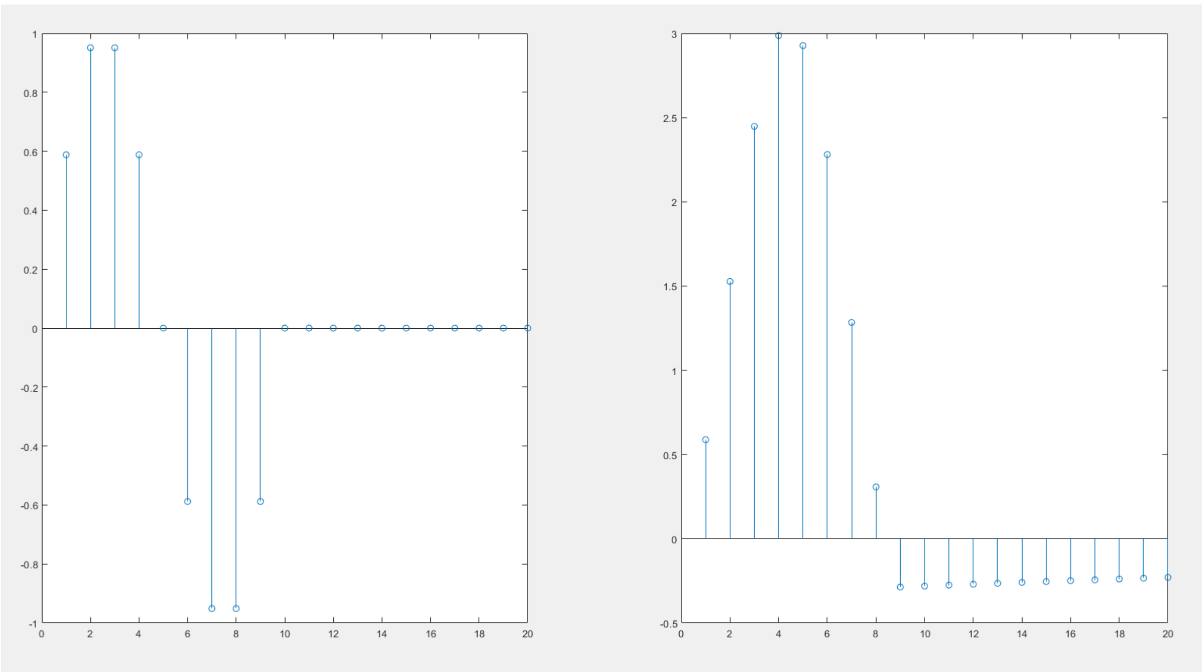
For the coding part:

```
n=1:10;
x=sin(pi/5 * n);
x=[x,zeros(1,10)];
n=1:1000;
h=0.98.^(n-1);

y=conv(x,h);
figure(1);
subplot(121);
stem(x(1:20));
subplot(122);
stem(y(1:20));
```

For the plot:





The distortion effects deform the signal of the original waveform. It first appears that the waveform shifted up after a few first signal pulses relative to the beginning of the start pulse;

after that, the original position signal pulses have been dropped to -0.9, but the signal pulses after distortion have been smoothed out to -0.2. Finally, the original signal pulses have been shifted down from 0 to -0.2. A lot of noises have interrupted the original signal pulses. That's distortion effects on h[n].

b)

b) Compute and plot $v[n] = g[n] * y[n]$ for $0 \leq n \leq 20$ where $g[n] = \delta[n-5] - 0.98\delta[n-6]$. Discuss the quality of $g[n]$ as an echo cancellation filter.

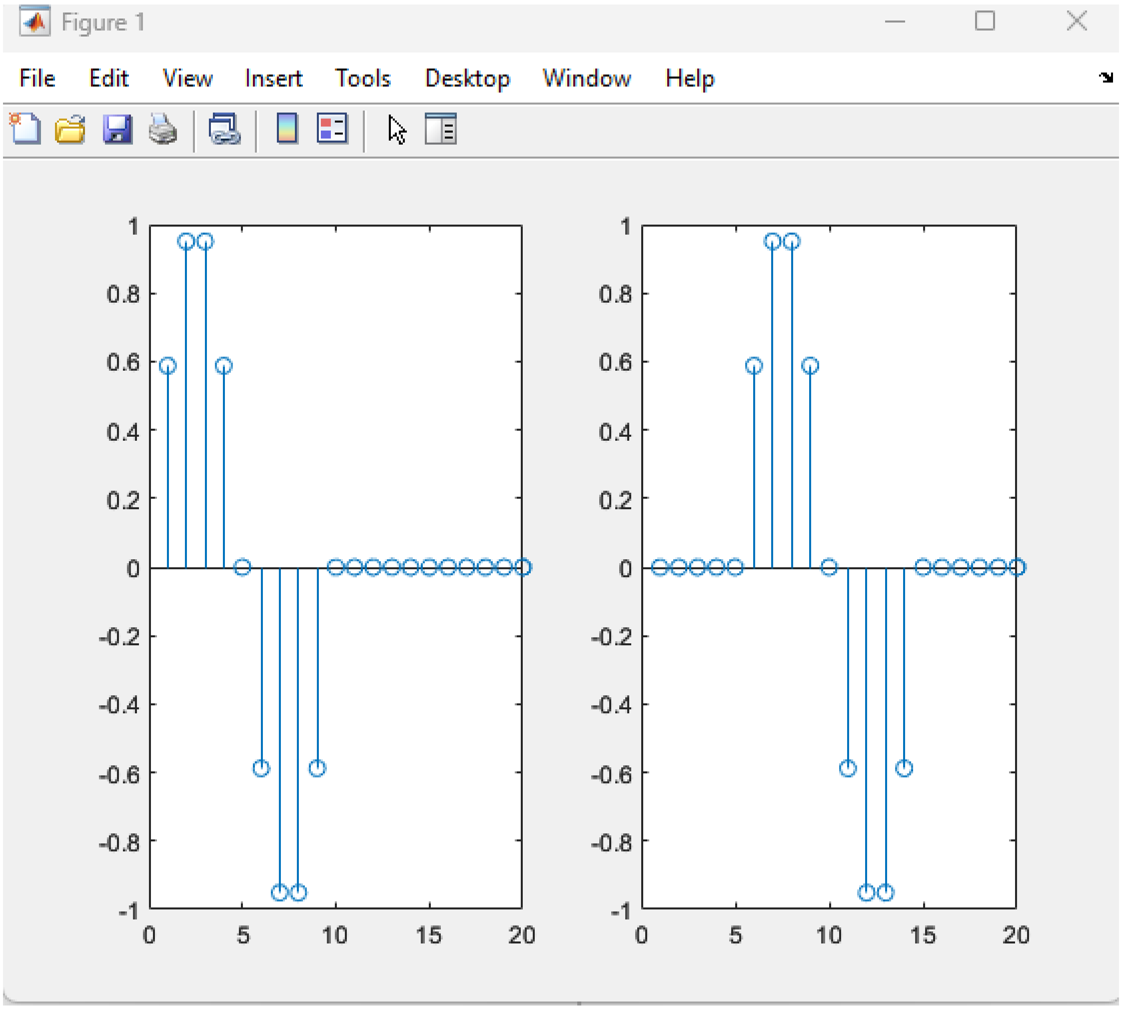
For the coding part

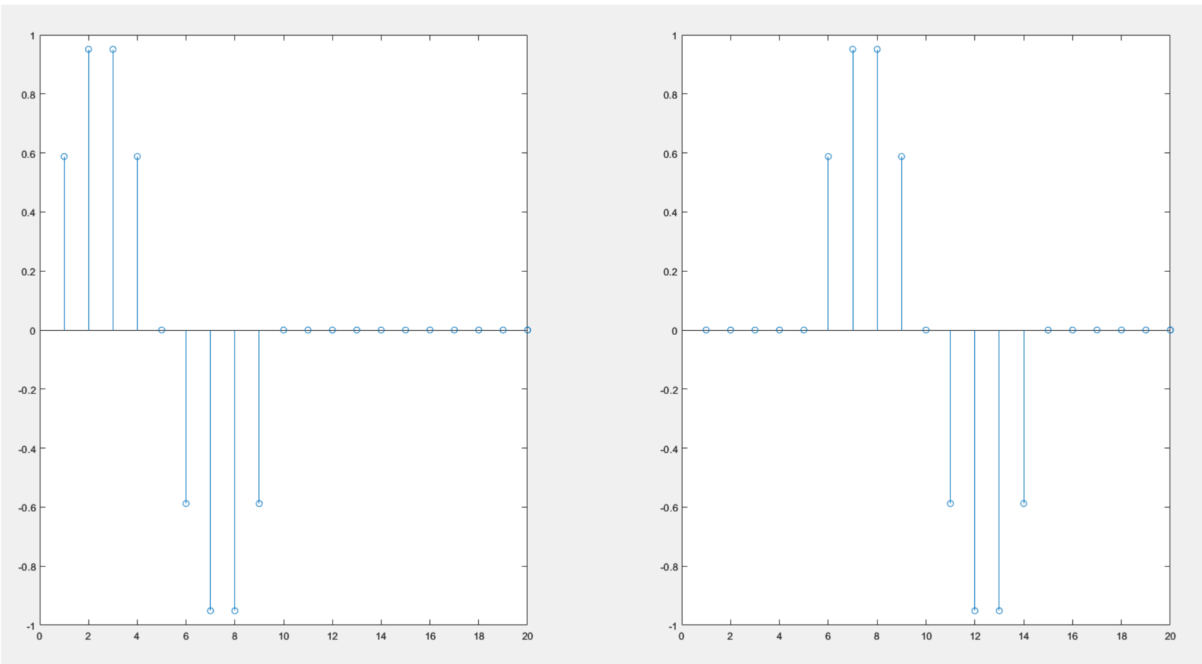
```
n=1:10;
x=sin(pi/5 * n);
x=[x,zeros(1,10)];
n=1:1000;
h=0.98.^(n-1);

y=conv(x,h);


g=zeros(1,10);
g(6)=1;
g(7)=-0.98;
v=conv(y,g);
figure(1);
subplot(121);
stem(x(1:20));
subplot(122);
stem(v(1:20));
```

For the plotting part:





The quality of g[n] as an echo noise cancellation:

The quality of g[n] is trying to smooth out the signal pulses from (a) in order to form the signal back to the original signal pulses. Using g[n] noise filter, it tries to cancel all the distortion signal pulses from (a) back to the original signal pulses quality. That's the quality of g[n] noise filter. As a comparison, g[n] has brought the distorted signal pulses from -0.2 back to -0.9 by canceling all the noises from (a)

3)

3) If $h[n] = a^n u[n] - b^n u[n]$ (which is the impulse response of a second-order feedback system), then its DTFT is $H(f) = \frac{1}{1-ae^{-j2\pi f}} - \frac{1}{1-be^{-j2\pi f}} = \frac{(a-b)e^{-j2\pi f}}{1-(a+b)e^{-j2\pi f}+abe^{-j4\pi f}}$. A good inverse filter of $H(f)$ has the frequency response $G(f) = 1 - (a+b)e^{-j2\pi f} + abe^{-j4\pi f}$. Assume the same $x[n]$ in (2) but $h[n] = 0.98^n u[n] - (-0.95)^n u[n]$.

a) Compute and plot $y[n] = x[n] * h[n]$ for $0 \le n \le 20$ (with a large L such that $h[L]$ is negligible). Discuss the distortion effect by $h[n]$.

For the coding part:

```
n=1:10;
x=sin(pi/5 * n);
x=[x,zeros(1,10)];
n=1:1000;
h=0.98.^(n-1) - (-0.95) .^(n-1);

y=conv(x,h);
figure(1);
subplot(121);
stem(x(1:20));
subplot(122);
stem(y(1:20));
```

For the plotting part:

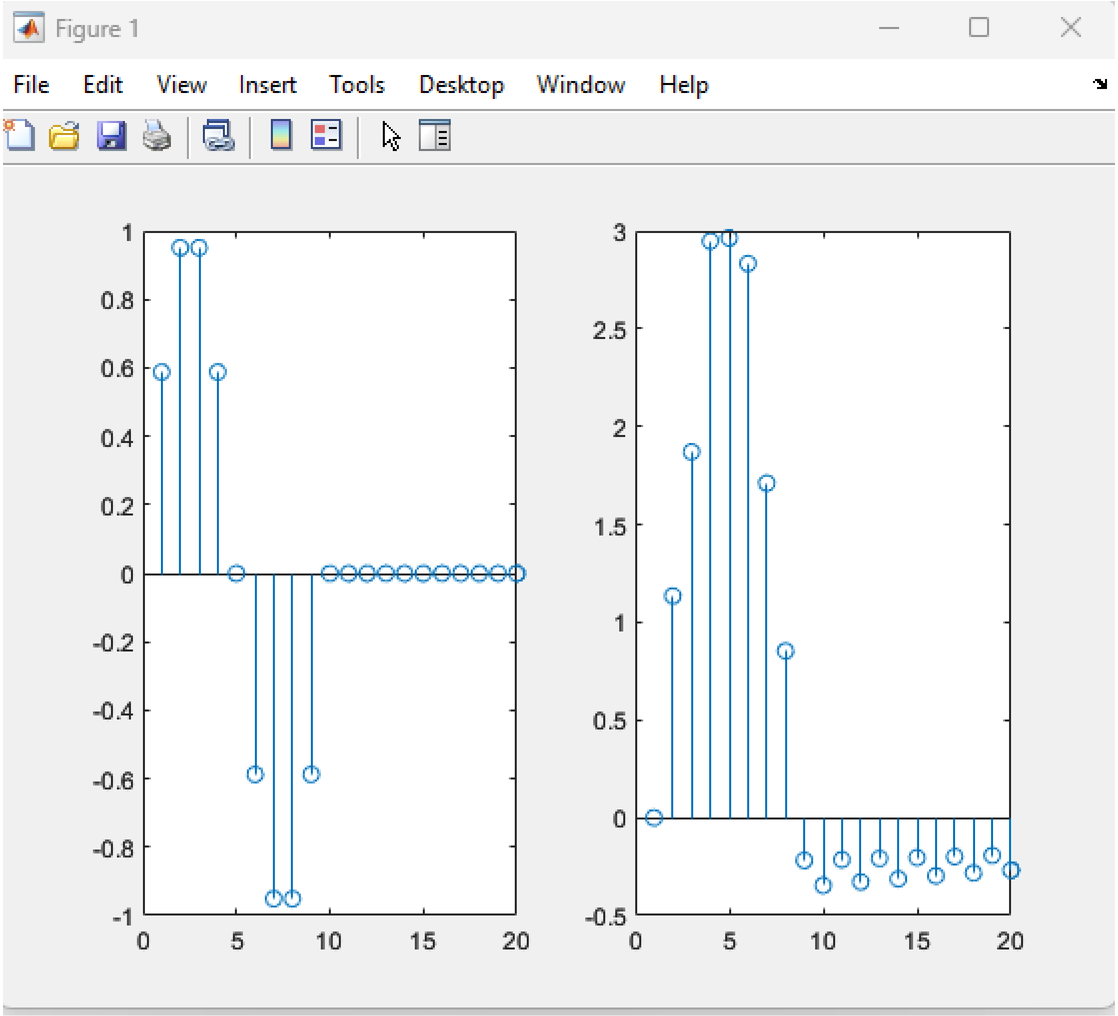


Figure 1
File
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Tools
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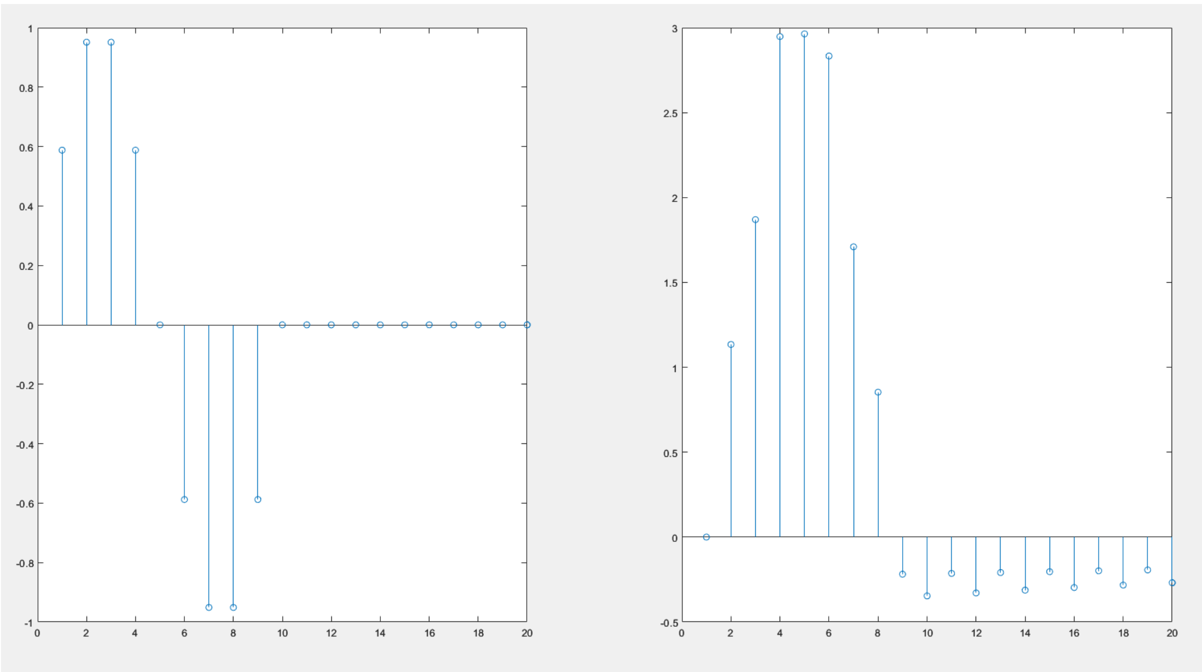
Help
1 0.8 0.6 0.4 0.2 0 -0.2 -0.4 -0.6 -0.8 -1
0 5 10 15 20
3 2.5 2 1.5 1 0.5 0 -0.5
0 5 10 15 20


1 0.8 0.6 0.4 0.2 0 -0.2 -0.4 -0.6 -0.8 -1
0 2 4 6 8 10 12 14 16 18 20
3 2.5 2 1.5 1 0.5 0 -0.5
0 2 4 6 8 10 12 14 16 18 20

The distortion effects deform the signal of the original waveform. It first appears that the waveform shifted up after a few first signal pulses relative to the beginning of the start pulse; after that, the original position signal pulses have been dropped to -0.9, but the signal pulses after distortion have been smoothed out to -0.2. Finally, the original signal pulses have been shifted down from 0 to -0.2. A lot of noises have interrupted the original signal pulses. That's distortion effects on h[n].

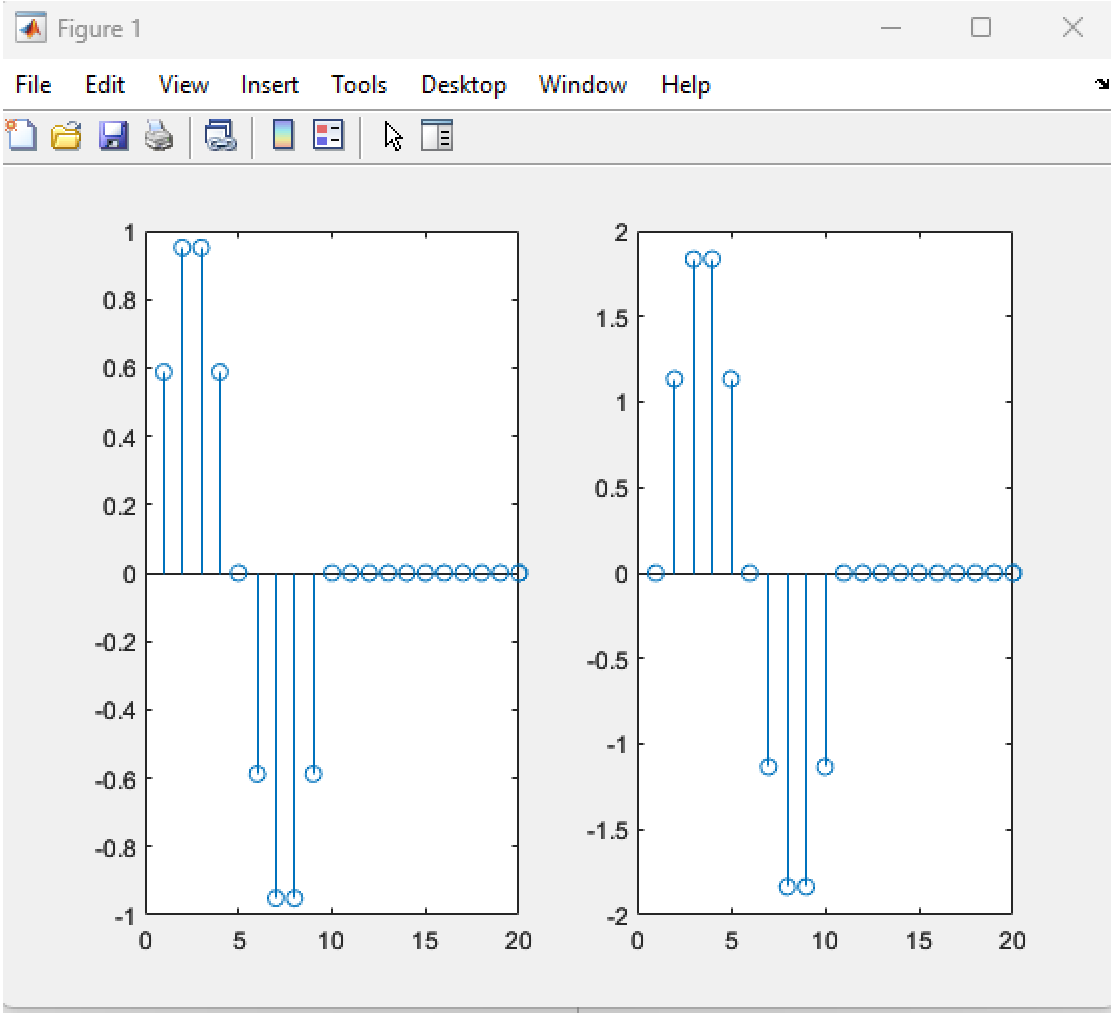
b)

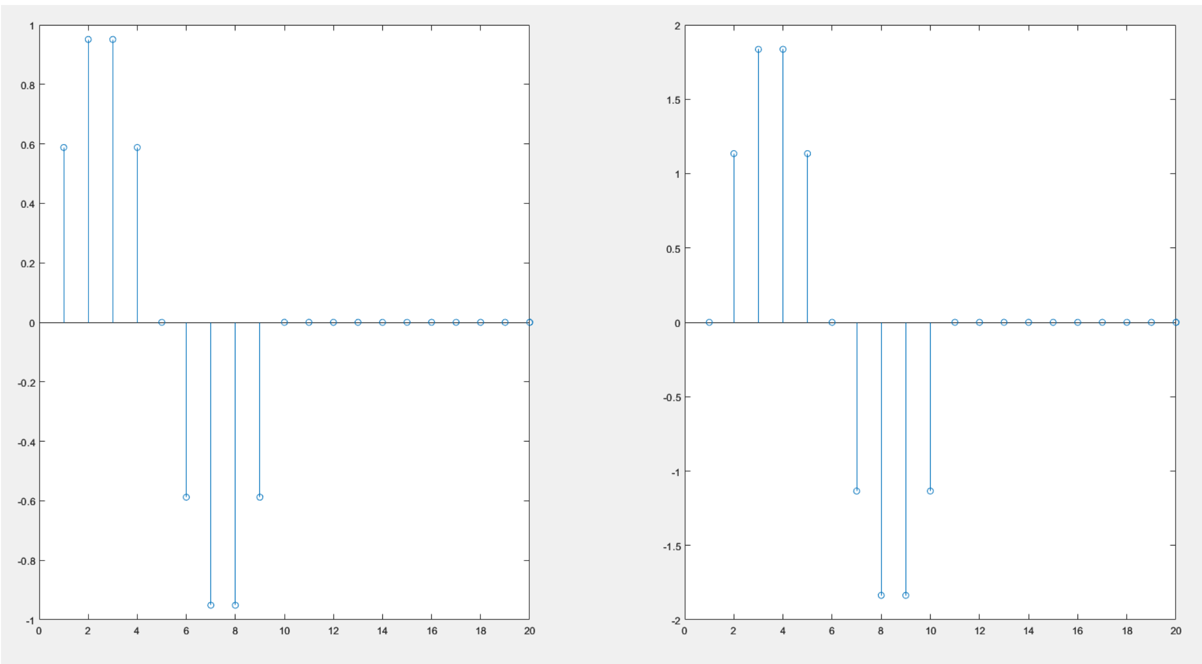
b) Compute and plot $v[n] = g[n] * y[n]$ for $0 \leq n \leq 20$ with $g[n] = \delta[n] - (a+b)\delta[n-1] + ab\delta[n-2]$, $a = 0.98$ and $b = -0.95$. Discuss the quality of $g[n]$ as an echo cancellation filter.

For the coding part:

```
n=1:1000;
h=0.98.^(n-1) - (-0.95).^(n-1);

y=conv(x,h);


g=zeros(1,5);
a=0.98;
b=-0.95;
g(1)=1;
g(2)=-(a+b);
g(3)=a.*b;


v=conv(y,g);
figure(1);
subplot(121);
stem(x(1:20));
subplot(122);
stem(v(1:20));
```

For the plotting part:





The quality of g[n] as an echo noise cancellation:

The quality of g[n] is trying to smooth out the signal pulses from (a) to form the signal back to the original signal pulses. Using g[n] noise filter, it tries to cancel all the distortion signal pulses from (a) back to the original signal pulses quality. That's the quality of g[n] noise filter. As a comparison, g[n] has brought the distorted signal pulses from -0.2 back to -0.9 by canceling all the noises from (a)