SP Final Project Report

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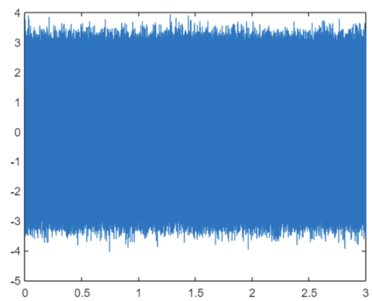
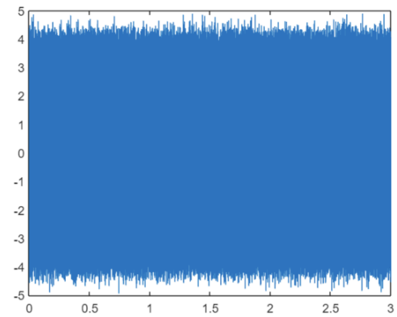
0.1 Question 1

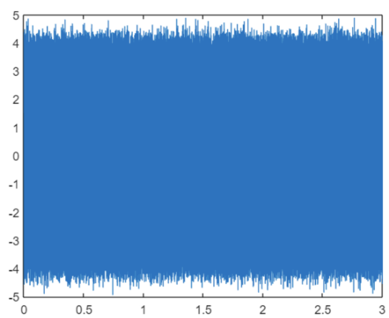
We first load Observation.nb.mat, which introduces all the variables needed in this section.



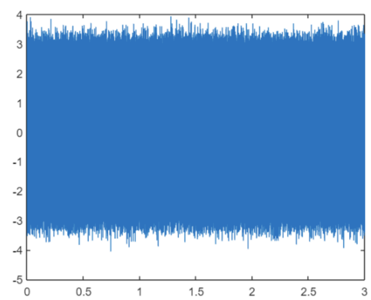
(a) time domain of microphone1



(b) time domain of microphone2



(c) time domain of microphone3

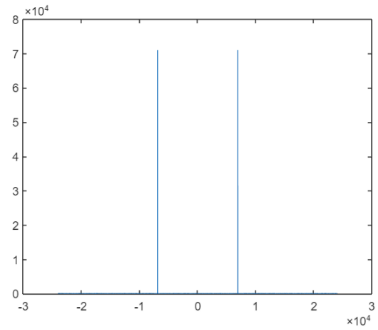


(d) time domain of microphone4

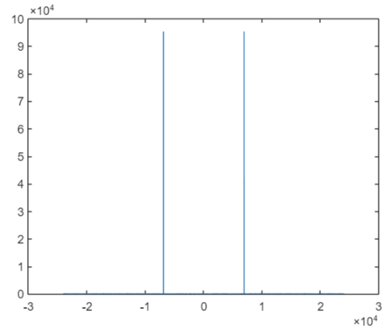
Figure 1: time domain

```
%time domain
t=1/16000:1/16000:3;
y1=y(:,1);
plot(t,y1)

t=1/16000:1/16000:3;
y2=y(:,2);
plot(t,y2)

t=1/16000:1/16000:3;
y3=y(:,3);
plot(t,y3)

t=1/16000:1/16000:3;
y4=y(:,4);
plot(t,y4)
```

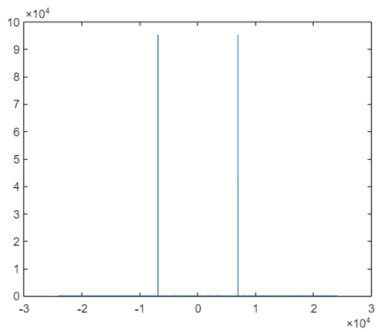
Plot the time domain of 4 microphones.



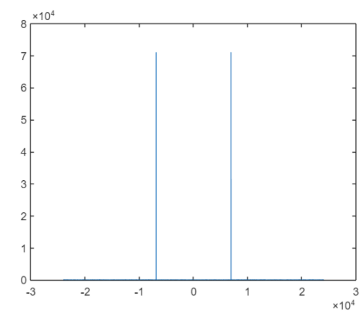
(a) frequency domain of microphone1



(b) frequency domain of microphone2



(c) frequency domain of microphone3



(d) frequency domain of microphone4

Figure 2: frequency domain

```
load("Observation_nb.mat")
%frequency domain
f=-23999:24000;
y_1=fftshift(abs(fft(real(y(:,1)))));
plot(f,y_1)

f=-23999:24000;
y_2=fftshift(abs(fft(real(y(:,2)))));
plot(f,y_2)

f=-23999:24000;
y_3=fftshift(abs(fft(real(y(:,3)))));
plot(f,y_3)

f=-23999:24000;
y_4=fftshift(abs(fft(real(y(:,4)))));
plot(f,y_4)
```

Plot the frequency domain of 4 microphones.

```
%find center frequency
fc=6899/3 %hz %换算单位 从0-24000换到0-8000hz
```

Find the center frequency from the figure of frequency domain.

```
%求协方差矩阵 Rx
Xk=[fft(y(:,1)),fft(y(:,2)),fft(y(:,3)),fft(y(:,4))];
Xk_t=Xk.';
Rx=(Xk_t*Xk_t')/48000;
Rx;
```

Find Rx, according to the fomula$Rx = \frac{1}{N} \cdot \sum_{k=1}^{N} x[k] \cdot x[k]'$
x[k] is a 4*48000 matrix, x[k]*x[k]' is a 4*4 matrix and N is48000.

```
[V,D]=eig(Rx);
[d,ind]=sort(diag(D));
vector1=V(:,ind(1));
vector2=V(:,ind(2));
Un=[vector1,vector2];
```

Find two min eigenvalue's corresponding eigenvectors.

```
%算a(theta)
angle_p=zeros(1,181);
p_value_1=zeros(1,181);
p_value_2=zeros(1,181);
a=1;
for theta=-pi/2:pi/180:pi/2;
    a_theta_1=zeros(1,4);        %time_difference = d'*v./340;
    a_theta_2=zeros(1,4);        %a_theta = exp(-j*2*pi*time_difference*2300).';

    for J=1:4;
        a_theta_1(1,J)=exp((-i*2*pi*((J-1)*0.034-0.051)*sin(theta))/(340/fc));

    end
    a_theta_t_1=a_theta_1.';
    p_theta_1=1/((a_theta_t_1')*Un*(Un')*a_theta_t_1);
    p_value_1(a)=p_theta_1;


    angle_p(a)=theta;
    a=a+1;
end
```

Find a(theta),according to the formula below.

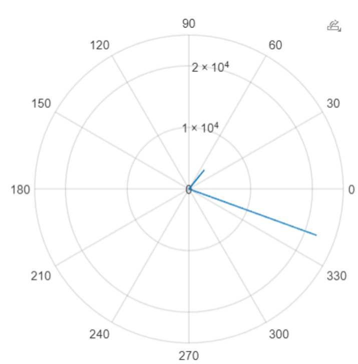
$$\underline{\mathbf{a}}(\theta) = [1, e^{-j2\pi\frac{d\sin\theta}{\lambda}}, \cdots, e^{-j2\pi(J-1)\frac{d\sin\theta}{\lambda}}]^t$$

```
p_value=p_value_1';
theta = -90:1:90;

P_middle = abs(p_value(2:end-1));
P_front = abs(p_value(1:end-2));
P_back = abs(p_value(3:end));
logic_front = (P_middle - P_front)>0;
logic_back = (P_middle - P_back)>0;
logic = logic_front & logic_back;
P_middle(~logic) = min(P_middle);
P_local = [abs(p_value(1));P_middle;abs(p_value(end))];
[~,doa_Idx] = maxk(P_local,2);
doa = theta(doa_Idx);
[~,minIdx] = min(abs(doa));
doa_source = doa(minIdx);
[~,maxIdx] = max(abs(doa));
interfer = doa(maxIdx);
disp(['The desired source DOA with MUSIC is: ',num2str(doa_source),' deg']);
disp(['The interfering DOA with MUSIC is: ',num2str(interfer),' deg']);
```

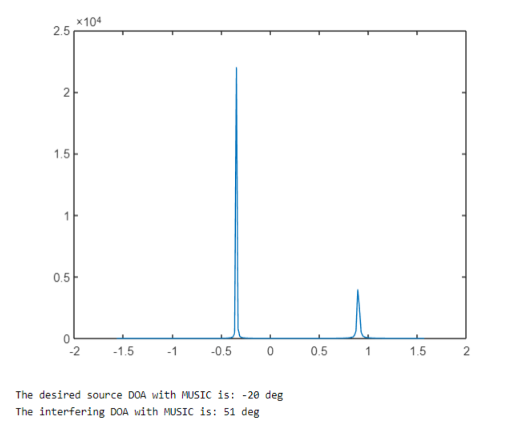
Use the provided code to find two directions of both the desired narrowband source signal and the second interfering signal.

```
polarplot(angle_p,real(p_value_1))
plot(angle_p,real(p_value_1))
```

Plot the figure of 'doa estimation' and 'pseudo spatial spectrum'.



(a) doa



(b) spectrum

Figure 3: the second question