Lab 5：System, Convolution and Filter

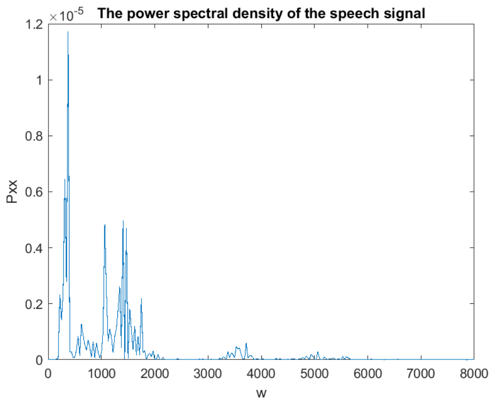
Author	Name：袁通 代育津 Student ID: 11810818 11910114

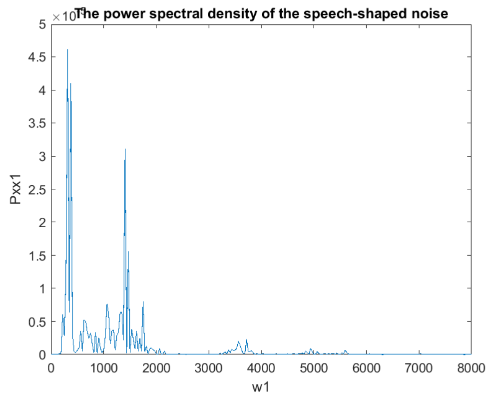
Introduction：

In this lab, we will process the speech signal for further analysis.
In task I, we will try to generate a speech-shaped noise.
In task II, we will try to add some noise to the signal.
In task III, we will extract the envelop of the signal.

Lab results & Analysis：

1. Generate a speech-shaped noise (SSN), and plot the spectra of the speech signal and SSN (e.g., use Matlab function 'psd' or 'pwelch', or other power spectral density estimation functions).



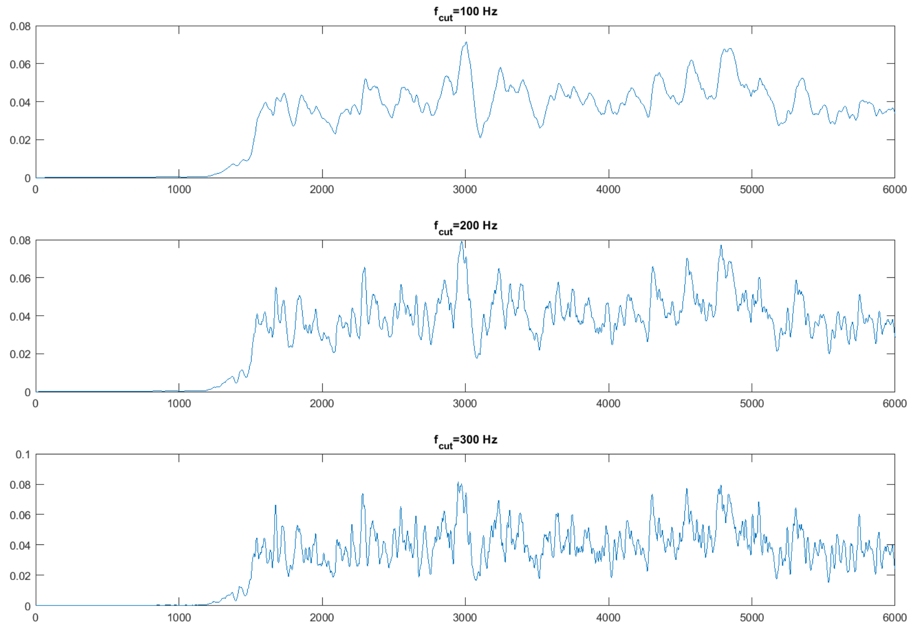


As shown in the figures, the first figure is the power spectral density of the speech signal and the second figure is the power spectral density of the speech-shaped niose.

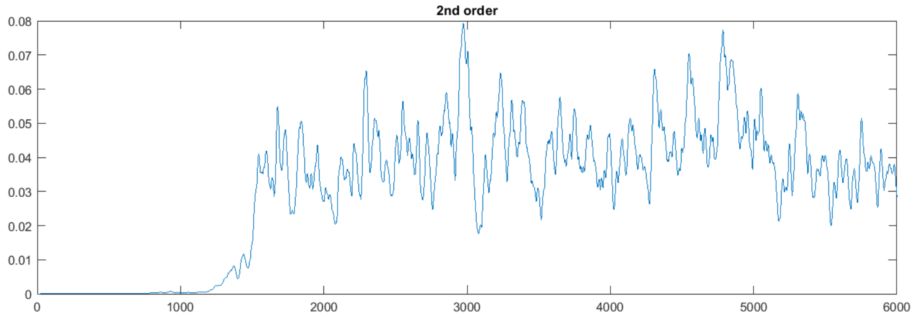
2. Read a speech signal x(t), adjust the SNR (x(t) to the above SSN) to -5 dB, let $y = x + SSN$, and normalize the energy of y in relative to x(t), i.e., modify the energy of y so that it equals to the energy of x.

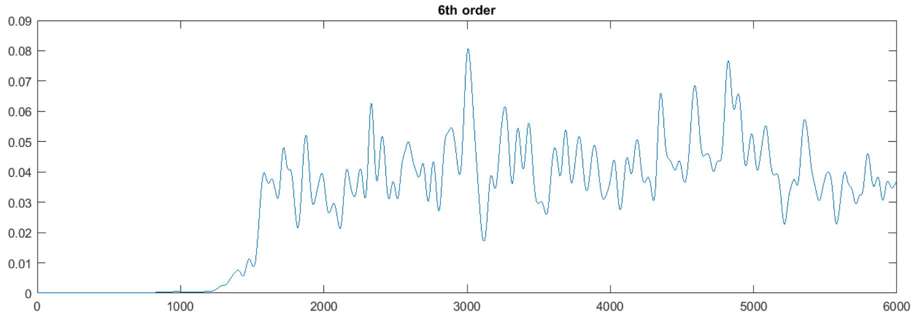
3. Extract speech envelope
   1) with 2^{nd}-order low-pass filter and cutoff frequency f_{cut}= 100, 200, and 300 Hz. Plot these three envelope waveforms in one plot, and describe the difference among them.
   2) with 2^{nd} and 6^{th}-order low-pass filter and cutoff frequency 200 Hz. Plot these two envelope waveforms in one plot, and describe the difference between them.

As shown in the figure, when we increase the cut off frequency, we find that more details in the signal, in other words, the signal contained in high frequency domain, appears.



We can see in the figure as the number of order increase, the details in the signal, or the high frequency signal is filtered.





Source Code

```
%5.1
[y1,fs]=audioread('C_01_01.wav');
y1=y1';
%sound(y,fs);
sig=repmat(y1,1,10);
N = length(y1);
noise=1-2*rand(1,N);
[Pxx,w]=pwelch(sig,[],[],512,fs);
figure(1);
plot(w,Pxx);
title('The power spectral density of the speech signal');
xlabel('w');
ylabel('Pxx');
saveas(gcf, "plots/P5_1_out1.png");
close;

b=fir2(3000,w/(fs/2),sqrt(Pxx/max(Pxx)));
[h,wh]=freqz(b,1,128);
ssn=filter(b,1,noise);
[Pxx1,w1]=pwelch(ssn,[],[],512,fs);
```

```
figure(2);
plot(w1,Pxx1);
title('The power spectral density of the speech-shaped noise');
xlabel('w1');
ylabel('Pxx1');
saveas(gcf, "plots/P5_1_out2.png");
close;


%5.2
ssn=norm(y1)*ssn/10^(-5/20)/norm(ssn);
snr=20*log10(norm(y1)/norm(ssn));
disp(snr);
y=y1+ssn;
y=y*norm(y1)/norm(y);

%5.3
y=abs(y);
figure(3);
[b,a]=butter(2,100/(fs/2));
envelop3=filter(b,a,y);
subplot(3,1,1);
plot(envelop3);
title('f_{cut}=100 Hz');
xlim([0,6000]);



[b,a]=butter(2,200/(fs/2));
envelop2=filter(b,a,y);
subplot(3,1,2);
plot(envelop2);
title('f_{cut}=200 Hz');
xlim([0,6000]);


[b,a]=butter(2,300/(fs/2));
envelop3=filter(b,a,y);
subplot(3,1,3);
plot(envelop3);
title('f_{cut}=300 Hz');
xlim([0,6000]);
saveas(gcf, "plots/P5_3_out1.png");
close;
```

```
figure(4);
[b,a]=butter(2,200/(fs/2));
envelop=filter(b,a,y);
subplot(2,1,1);
plot(envelop);
title('2nd order');
xlim([0,6000]);

[b,a]=butter(6,200/(fs/2));
envelop=filter(b,a,y);
subplot(2,1,2);
plot(envelop);
title('6th order');
xlim([0,6000]);
saveas(gcf, "plots/P5_3_out2.png");
close;
```

Note: Please indicate meaning of the symbols in all expressions. Please indicate the coordinate and unit in all figures.

Experience

In this lab, we learn how to generate the speech noise and extract the envelop from a signal. We found that the envelop is hide in the low frequency domain.

Score	

字体：英文 Times new Roman；中文宋体，正文五号

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