**Project 1**

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| **Question(a):**    **Analysis(a):**        As showed in spectrum, when cut-off frequency of LPF goes up, the energy of other frequency expects the medium frequency increase. In other words, more detail in stored with higher cut-off frequency.  When we heard the output audio signal, N = 8 f = 400Hz is the only signal we could vaguely understand what it’s conveying. And with a higher cut-off frequency, the comprehension easier.  Task4        The graph above is spectrum of original signal and noisy signal.  The following graphs is the spectrum of noisy signal generated by the tone-vocoder  With N=6 and cut off frequency = 20 50 100 400Hz.              Analysis:  The generated audio is hard to understand. Audio generated with higher cut-off frequency is clearer although there are still not understandable. There are 6 peeks in each side corresponding to N=6. With the cutoff frequency increasing, there appear more and more scattered signals between the peak, which happens in task2.  With bands increasing, it’s still hard to hear the sentence.  Conclusion:  Audio generated with more band and higher cutoff frequency sound clearer. Although too much bands can lead to strange sound effect. When the sound has much noise and it’s hard to understand, the generated audio by tone-vocode is hard to understand too. | |
| **Experience**  You can write your experience with this project. Any comment and suggestion on this course are also very welcome. | |
| **Score** |  |

字体：英文Times new Roman；中文宋体，正文五号

文件名统一命名方式：**LabX+姓名+学号**，**例如：Lab1+张三+00001 （正式报告删除此行！）**

**2.4.a**

clc;clf;clear;

x1 = [ones(1,5) zeros(1,5)];nx1 = 0:9;

h1 = [1 -1 3 0 1];nh1 = 0:4;

h2 = [0 2 5 4 -1];nh2 = 0:4;

subplot(3,1,1);

stem(nx1,x1);title('x1[n]');xlabel('n');ylabel('x1[n]')

subplot(3,1,2);

stem(nh1,h1);title('h1[n]');xlabel('n');ylabel('h1[n')

subplot(3,1,3)

stem(nh2,h2);title('h2[n]');xlabel('n');ylabel('h2[n]')

**2.4.b**

clc;clear;clf;

x1 = [ones(1,5) zeros(1,5)];

nx = 0:9;

h1 = [1 -1 3 0 1];nh1 = 0:4;

y1 = conv(x1,h1);

ny1 = nx(1)+nh1(1):nx(end)+nh1(end);

subplot(1,2,1)

stem(ny1,y1);title('x1[n]\*h1[n]');xlabel('n');ylabel('x1[n]\*h1[n]')

y2 = conv(h1,x1);

ny2 = nx(1)+nh1(1):nx(end)+nh1(end);

subplot(1,2,2)

stem(ny2,y2);title('h1[n]\*x1[n]');xlabel('n');ylabel('h1[n]\*x1[n]')

**2.4.c**

clc;clear;clf;

x1 = [ones(1,5) zeros(1,5)];nx1 = 0:9;

h1 = [1 -1 3 0 1];nh1 = 0:4;

h2 = [0 2 5 4 -1];nh2 = 0:4;

y1 = conv(x1,h1)+conv(x1,h2);

ny1 = nx1(1)+nh1(1):nx1(end)+nh1(end);

subplot(1,2,1)

stem(ny1,y1);title('x[n]\*h1[n]+x[n]\*h2[n]');

xlabel('n');ylabel('x[n]\*h1[n]+x[n]\*h2[n]');

y2 = conv(x1,h1+h2);

ny2 = nx1(1)+nh1(1):nx1(end)+nh1(end);

subplot(1,2,2)

stem(ny2,y2);title('x[n]\*(h1[n]+h2[n])');

xlabel('n');ylabel('x[n]\*(h1[n]+h2[n])');

**2.4.d**

clc;clear;clf;

x1 = [ones(1,5) zeros(1,5)];nx1 = 0:9;

h1 = [1 -1 3 0 1];nh1 = 0:4;

h2 = [0 2 5 4 -1];nh2 = 0:4;

w1 = conv(x1,h1);

nw1 = nx1(1)+nh1(1) : nx1(end)+nh1(end);

yd1 = conv(w1,h2);

nyd1 = nw1(1)+nh2(1) : nw1(end)+nh2(end);

subplot(1,2,1);stem(nyd1,yd1);title('(x[n]\*h1[n])\*h2[n]');

xlabel('n');ylabel('(x[n]\*h1[n])\*h2[n]');

hseries = conv(h1,h2);

nhseries = nh1(1)+nh2(1) : nh1(end)+nh2(end);

yd2 = conv(x1,hseries);

nyd2 = nx1(1)+nhseries(1) : nx1(end)+nhseries(end);

subplot(1,2,2);stem(nyd2,yd2);title('x[n]\*(h1[n]\*h2[n])');

xlabel('n');ylabel('x[n]\*(h1[n]\*h2[n])')

**2.4.e**

clc;clf;clear;

x1 = [ones(1,5) zeros(1,5)];nx1 = 0:9;

h1 = [1 -1 3 0 1];nh1 = 0:4;

he1 = [h1 0 0];nhe1 = 0:6;

he2 = [0 0 h1];nhe2 = 0:6;

ye1 = conv(he1,x1);

nye1 = nx1(1)+nhe1(1) : nx1(end)+nhe1(end);

subplot(3,1,1);stem(nye1,ye1);title('ye1=x[n]\*h1[n]')

xlabel('n');ylabel('ye1[n]');

ye2 = conv(he2,x1);

nye2 = nx1(1)+nhe2(1) : nx1(end)+nhe2(end);

subplot(3,1,2);stem(nye2,ye2);title('ye2=x[n]\*h1[n-2]')

xlabel('n');ylabel('ye2[n]');

ye3 = [0 0 ye1];

nye3 = nx1(1)+nhe1(1) : nx1(end)+nhe1(end)+2;

subplot(3,1,3);stem(nye3,ye3);axis([0 15 0 4]);title('ye1[n-2]')

xlabel('n');ylabel('ye1[n-2]');

**2.4.f**

clc;clear;clf;

% y[n] = (n+1)x[n]

x1 = [ones(1,5) zeros(1,5)];nx1 = 0:9;

w1 = (nx1+1).\*x1;

subplot(2,3,1);stem(nx1,w1);title('w')

xlabel('n');ylabel('w');

h1 = [1 -1 3 0 1];nh1 = 0:4;

yf1 = conv(w1,h1);

nyf1 = nx1(1)+nh1(1) : nx1(end)+nh1(end);

subplot(2,3,2);stem(nyf1,yf1);title('yf1');axis([0 10 0 4]);

xlabel('n');ylabel('yf1');

hf1 = [1 zeros(1,4)];nhf1 = 0:4;

subplot(2,3,3);stem(nhf1,hf1);title('hf1');

xlabel('n');ylabel('hf1');

hf2 = h1;

nhf2 = nh1;

hseries = conv(hf1,hf2);

nhseries = nhf1(1)+nhf2(1) : nhf1(end)+nhf2(end);

subplot(2,3,4);stem(nhseries,hseries);title('hseries');axis([0 10 0 4]);

xlabel('n');ylabel('hseries');

yf2 = conv(hseries,x1);

nyf2 = nhseries(1)+nx1(1) : nhseries(end)+nx1(end);

subplot(2,3,5);stem(nyf2,yf2);title('yf2');axis([0 10 0 4]);

xlabel('n');ylabel('yf2');

**2.4.g**

clc;clf;clear;

% S1：y[n] = x^2[n];

% S2：hg2[n] = h2[n];

h2 = [0 2 5 4 -1];nh2 = 0:4;

xg = [2 zeros(1,4)];

nxg = 0:4;

yga = xg.^2;

nyga = 0:4;

ygb = conv(xg,h2);

ngb = nxg(1)+nh2(1) : nxg(end)+nh2(end);

while length(yga)~=length(ygb)

yga = [yga 0];

end

yg1 = yga + ygb;

nyg1 = ngb;

x1 = [1 zeros(1,4)];

nx1 = 0:4;

hg1 = x1.^2;

nhg1 = nx1;

hg2 = h2;

nhg2 = nh2;

hparallel = hg2+x1;

nhparallel = nhg2;

yg2 = conv(xg,hparallel);

nyg2 = nxg(1)+nhparallel(1) : nxg(end)+nhparallel(end);

subplot(1,2,1);

stem(nyg1,yg1);title('yg1');

xlabel('n');ylabel('yg1');

subplot(1,2,2);

stem(nyg2,yg2);title('yg2');

xlabel('n');ylabel('yg2');

Task 4 Code

N = 6;

figure

X = fft(x)/length(x);

f = linspace(-fs/2, fs/2, length(x));

figure

plot(f,abs(fftshift(X)));

title('noisy signal X')

for i = [20 50 100 400]

y = tone\_vocoder(x,N,i,but\_order,fs);

figure

Y = fft(y)/length(y);

figure

plot(f,abs(fftshift(Y)));

title(sprintf('Q4 noisy signal N=%d f=%d Hz',N, i))

audiowrite(sprintf('Q4 noisy signal N=%d f=%d Hz.wav',N, i),y,fs)

end