ECE 311 Lab 7

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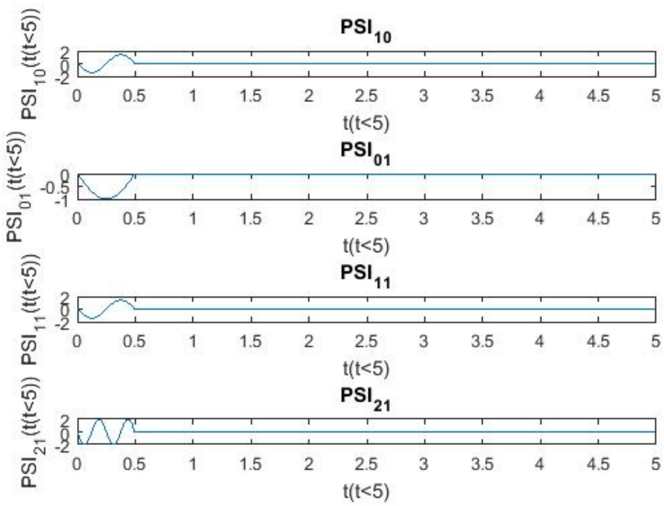
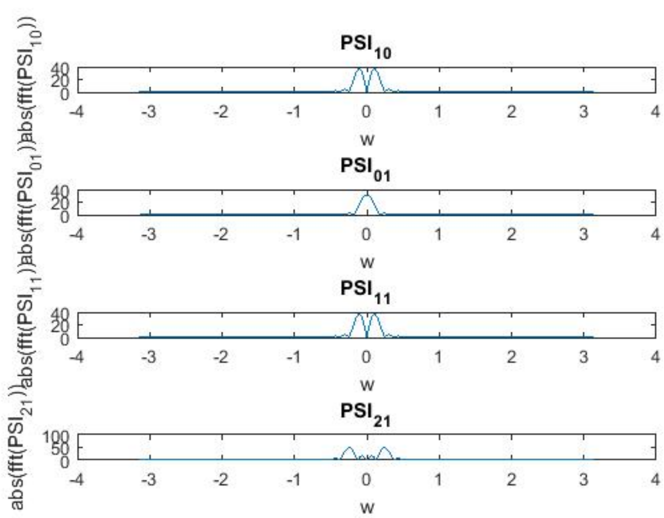
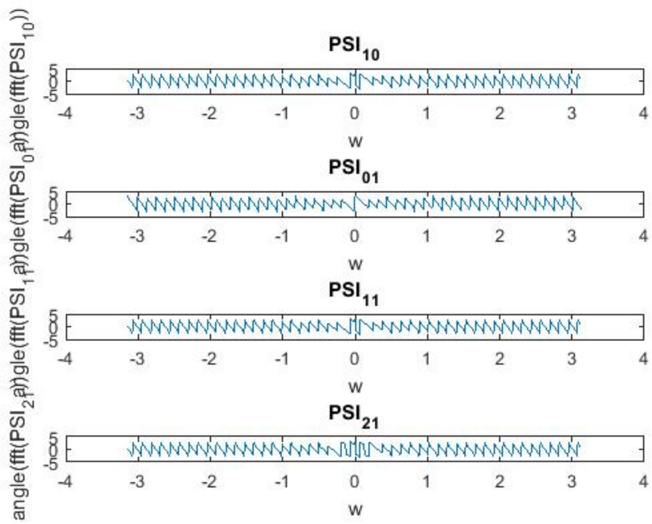
Report Item 1

```
t = 0:.01:5.11;
st = t(t<.5);

PSI_1_0 = sin(2*pi*(st*2 + .5));
PSI_1_0 = PSI_1_0 * 2^(.5);
PSI_1_0(end:512) = 0;
figure;
subplot(411);
plot(t(1:500),PSI_1_0(1:500));
title('PSI_1_0')
xlabel('t(t<5)');
ylabel('PSI_1_0(t(t<5))');

PSI_0_1 = sin(2*pi*(st - 1 + .5));
PSI_0_1(end:512) = 0;
subplot(412);
plot(t(1:500),PSI_0_1(1:500));
title('PSI_0_1')
xlabel('t(t<5)');
ylabel('PSI_0_1(t(t<5))');

PSI_1_1 = sin(2*pi*(st*2 - 1 + .5));
PSI_1_1 = PSI_1_1 * 2^(.5);
PSI_1_1(end:512) = 0;
subplot(413);
plot(t(1:500),PSI_1_1(1:500));
title('PSI_1_1')
xlabel('t(t<5)');
ylabel('PSI_1_1(t(t<5))');

PSI_2_1 = sin(2*pi*(st*4 - 1 + .5));
PSI_2_1 = PSI_2_1 * 2^(1);
PSI_2_1(end:512) = 0;
subplot(414);
plot(t(1:500),PSI_2_1(1:500));
title('PSI_2_1')
xlabel('t(t<5)');
ylabel('PSI_2_1(t(t<5))');

w = fftshift((0:511)/512*2*pi);
w(1:512/2) = w(1:512/2) - 2*pi;
```

```
figure;
subplot(411);
plot(w,abs(fftshift(fft(PSI_1_0))));
title('PSI_1_0')
xlabel('w');
ylabel('abs(fft(PSI_1_0))');
subplot(412);
plot(w,abs(fftshift(fft(PSI_0_1))));
title('PSI_0_1')
xlabel('w');
ylabel('abs(fft(PSI_0_1))');
subplot(413);
plot(w,abs(fftshift(fft(PSI_1_1))));
title('PSI_1_1')
xlabel('w');
ylabel('abs(fft(PSI_1_1))');
subplot(414);
plot(w,abs(fftshift(fft(PSI_2_1))));
title('PSI_2_1')
xlabel('w');
ylabel('abs(fft(PSI_2_1))');

figure;
subplot(411);
plot(w,angle(fftshift(fft(PSI_1_0))));
title('PSI_1_0')
xlabel('w');
ylabel('angle(fft(PSI_1_0))');
subplot(412);
plot(w,angle(fftshift(fft(PSI_0_1))));
title('PSI_0_1')
xlabel('w');
ylabel('angle(fft(PSI_0_1))');
subplot(413);
plot(w,angle(fftshift(fft(PSI_1_1))));
title('PSI_1_1')
xlabel('w');
ylabel('angle(fft(PSI_1_1))');
subplot(414);
plot(w,angle(fftshift(fft(PSI_2_1))));
title('PSI_2_1')
xlabel('w');
ylabel('angle(fft(PSI_2_1))');
```


PSI_10
PSI_10(t(t<5))
2
0
-2
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
t(t<5)
PSI_01
PSI_01(t(t<5))
0
-0.5
-1
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
t(t<5)
PSI_11
PSI_11(t(t<5))
2
0
-2
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
t(t<5)
PSI_21
PSI_21(t(t<5))
2
0
-2
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
t(t<5)


PSI_10
abs(fft(PSI_10))
40
20
0
-4 -3 -2 -1 0 1 2 3 4
w
PSI_01
abs(fft(PSI_01))
40
20
0
-4 -3 -2 -1 0 1 2 3 4
w
PSI_11
abs(fft(PSI_11))
40
20
0
-4 -3 -2 -1 0 1 2 3 4
w
PSI_21
abs(fft(PSI_21))
100
50
0
-4 -3 -2 -1 0 1 2 3 4
w



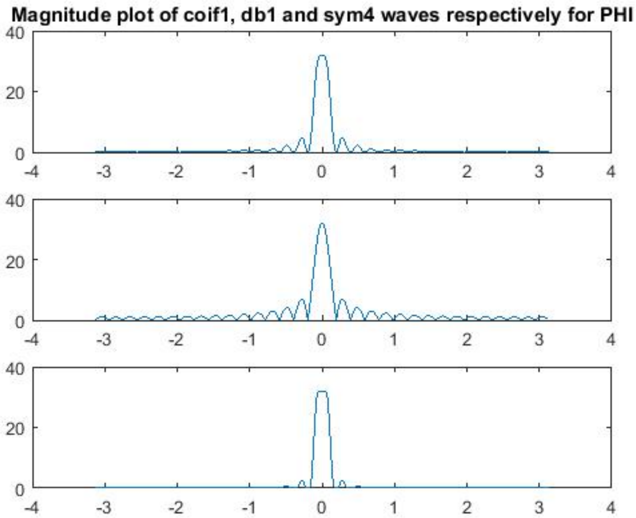
As you can see the by the graphs above, the waves with overlapping frequency components are considered orthonganol. Wavelets with different oscillation rates are orthoganol. By the magnitude plot at the zero frequency component we can get the DC component. For Psi 01, 10, 11, 21 they are 0, 20, 0 and 0 respectively.

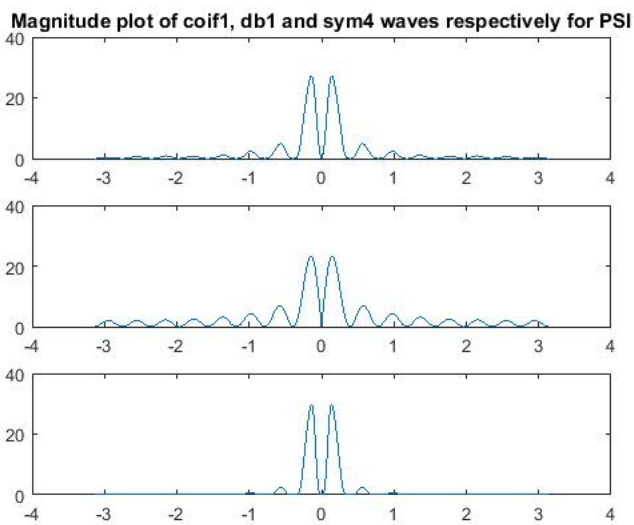
Report Item 2 The father wavelet is called a corking function because it fills up the holes of the lower frequency components that the mother wavelets do not detect. The wavelet coeffiecients are different than fourier coefficients because in wavelet analysis, a short modulated window is used to complete the spectral representation for that chunk. After that, the window is shifted along the signal. It is a time-frequency analysis instead a purely frequency analysis.

Report Item 3

```
[PHI1,PSI1,t1] = wavefun('coif1',5);
[PHI2,PSI2,t2] = wavefun('db1',5);
[PHI3,PSI3,t3] = wavefun('sym4',5);

w = fftshift((0:511)/512*2*pi);
w(1:512/2) = w(1:512/2) - 2*pi;

PH1w = fftshift(fft(PHI1,512));
PH2w = fftshift(fft(PHI2,512));
PH3w = fftshift(fft(PHI3,512));
PS1w = fftshift(fft(PSI1,512));
PS2w = fftshift(fft(PSI2,512));
PS3w = fftshift(fft(PSI3,512));

figure;
subplot(311);
plot(w,abs(PH1w));
title('Magnitude plot of coif1, db1 and sym4 waves respectively for
    PHI');

subplot(312);
plot(w,abs(PH2w));
subplot(313);
plot(w,abs(PH3w));


figure;

subplot(311);
plot(w,abs(PS1w));
title('Magnitude plot of coif1, db1 and sym4 waves respectively for
    PSI');
subplot(312);
plot(w,abs(PS2w));
subplot(313);
plot(w,abs(PS3w));
```

report2.m

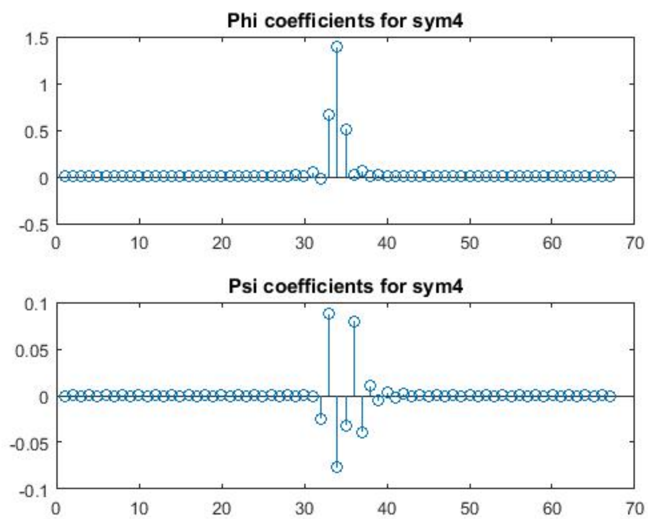

Magnitude plot of coif1, db1 and sym4 waves respectively for PHI
40
20
0
-4 -3 -2 -1 0 1 2 3 4

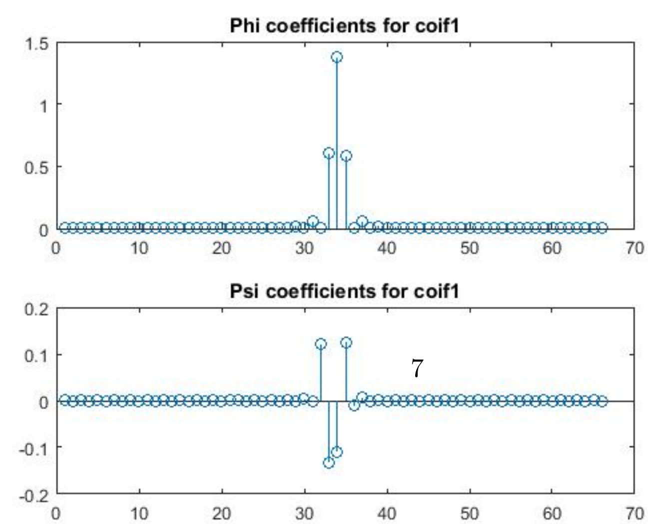

Magnitude plot of coif1, db1 and sym4 waves respectively for PSI
40
20
0
-4 -3 -2 -1 0 1 2 3 4

Report Item 4

```
load signal.mat;
[A1,D1] = dwt(x,'sym4');
[A2,D2] = dwt(x,'coif1');

figure;
subplot(211);
stem(A1);
title('Phi coefficients for sym4');
subplot(212);
stem(D1);
title('Psi coefficients for sym4');

figure;
subplot(211);
stem(A2);
title('Phi coefficients for coif1');
subplot(212);
stem(D2);
title('Psi coefficients for coif1');
```

report3.m



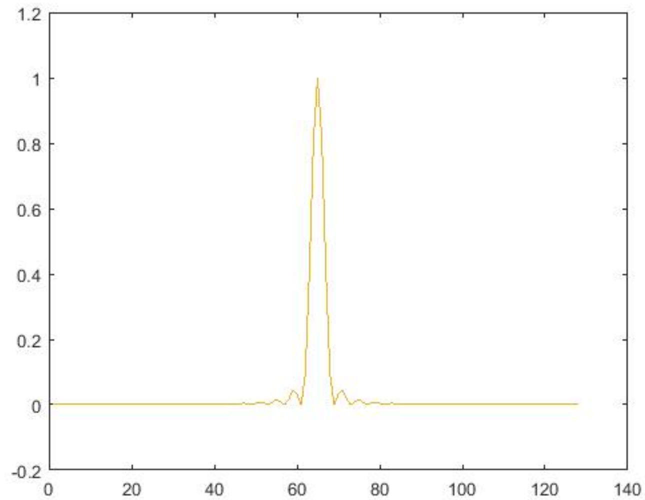


Report Item 5

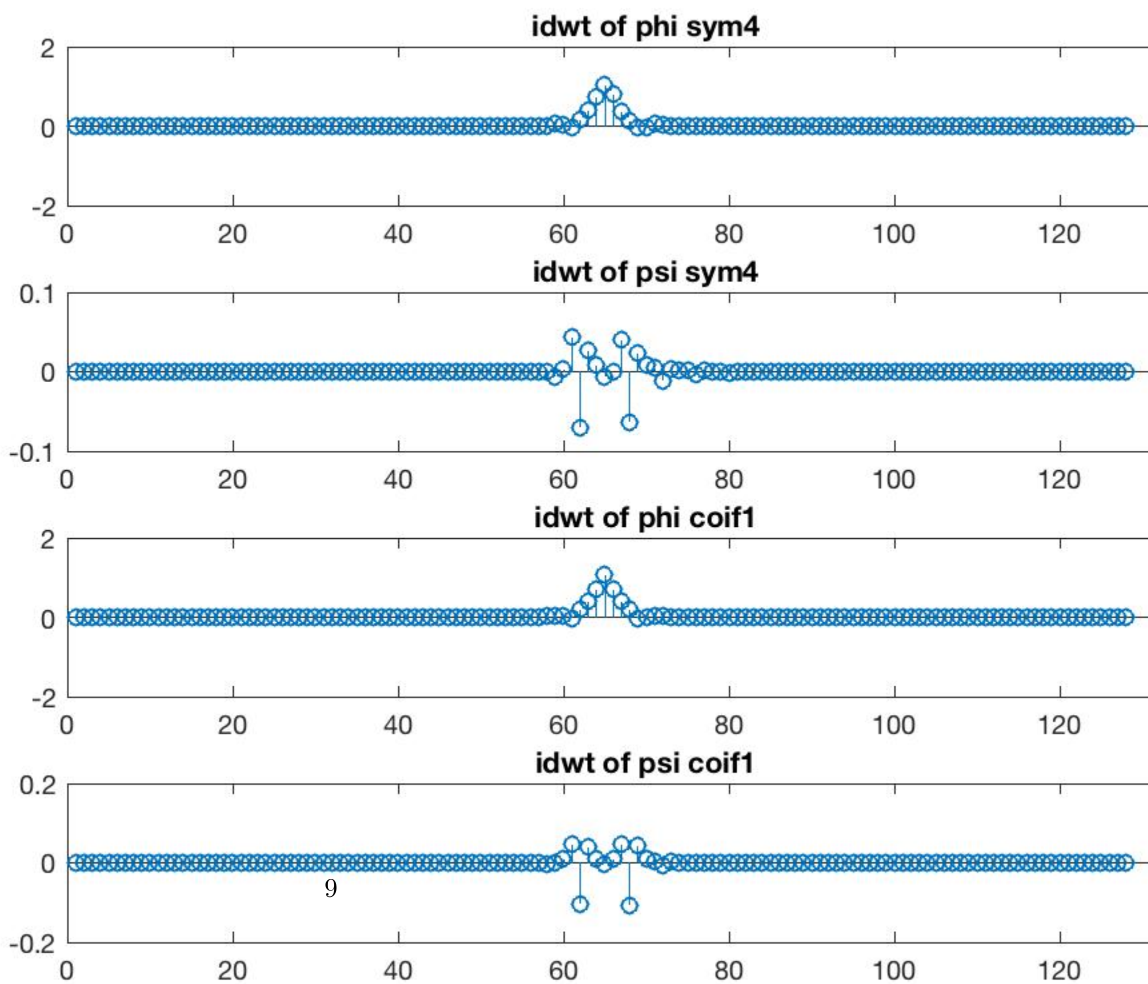
```
load signal.mat;
[A1,D1] = dwt(x,'sym4');
[A2,D2] = dwt(x,'coif1');
xnew1 = idwt(A1,D1,'sym4');
xnew2 = idwt(A2,D2,'coif1');
figure;
plot(x);
hold on;
plot(xnew1);
plot(xnew2);
% plot shows same graph overlayed 3 times

A1mean = mean(A1);
A2mean = mean(A2);
D1mean = mean(D1);
D2mean = mean(D2);
A1(A1 < A1mean) = 0;
A2(A2 < A2mean) = 0;
D1(D1 < D1mean) = 0;
D2(D2 < D2mean) = 0;
x1 = idwt(A1,[],'sym4');
x2 = idwt([],D1,'sym4');
x3 = idwt(A2,[],'coif1');
x4 = idwt([],D2,'coif1');

figure
subplot(411);
stem(x1);
title('idwt of phi sym4');
subplot(412);
stem(x2);
title('idwt of psi sym4');
subplot(413);
stem(x3);
title('idwt of phi coif1');
subplot(414);
stem(x4);
title('idwt of psi coif1');
```

report4.m

For this plot I overlayed the different waves to show that they are the



same.

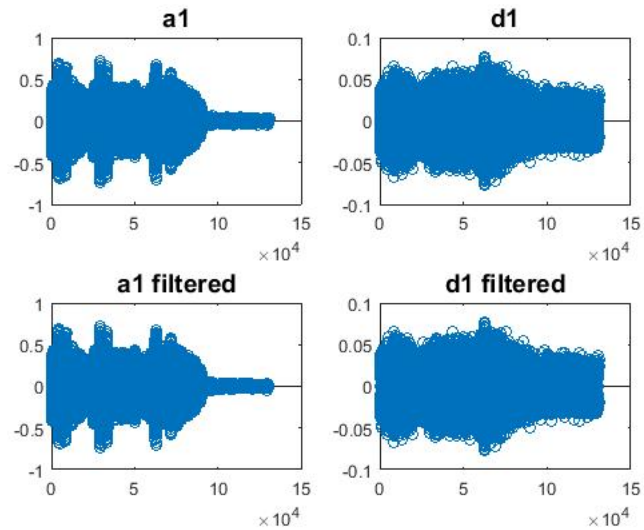


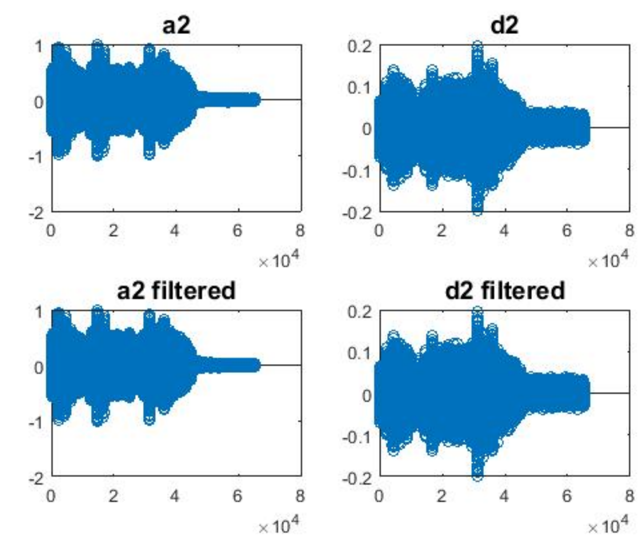
Report Item 6

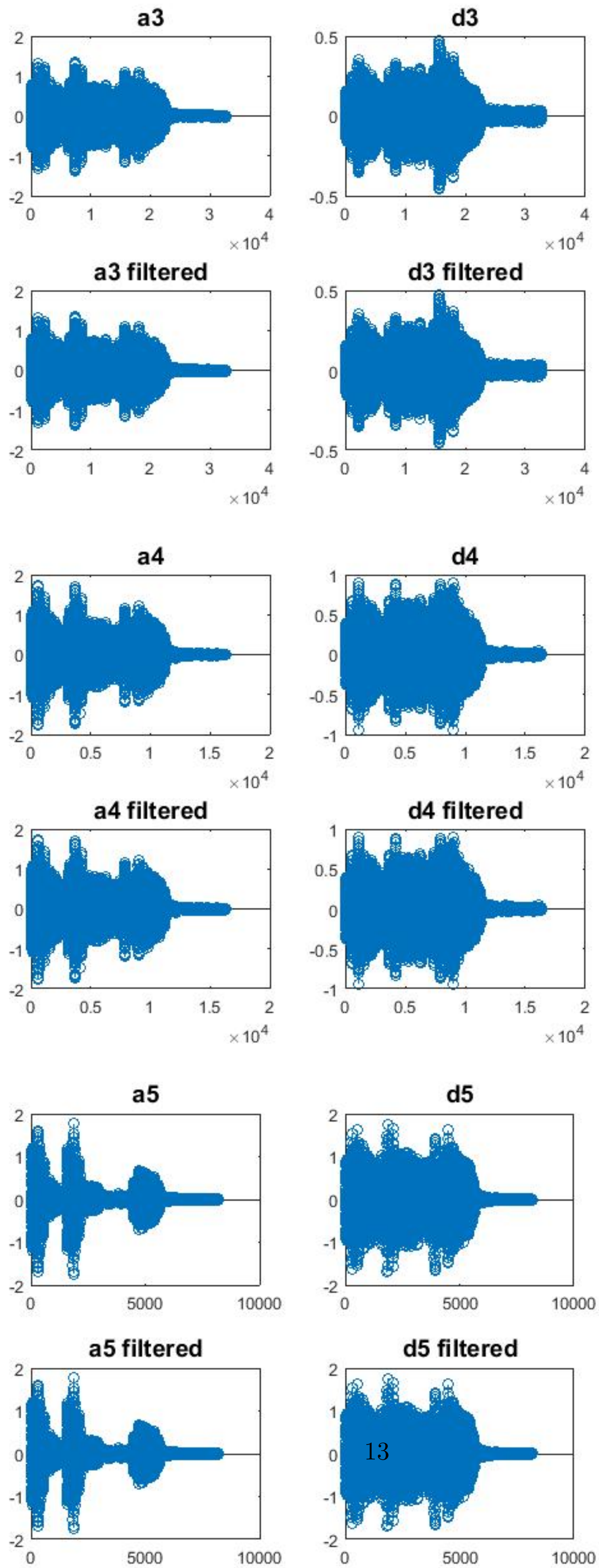
```
clc, clear all, close all

[xorig,fs] = audioread('original.wav');
[xnoise,fs] = audioread('noisy.wav');

wname = 'db1';


a1thresh = 0.016; % Must be positive.
d1thresh = 0.009; % Must be positive.
a2thresh = 0.016; % Must be positive.
d2thresh = 0.0; % Must be positive.
a3thresh = 0.02; % Must be positive.
d3thresh = 0.012; % Must be positive.
a4thresh = 0.0060; % Must be positive.
d4thresh = 0.012; % Must be positive.
a5thresh = 0.002; % Must be positive.
d5thresh = 0.016; % Must be positive.

% DWT
x = xnoise;
[a1,d1] = dwt(x,wname);
[a2,d2] = dwt(a1,wname);
[a3,d3] = dwt(a2,wname);
[a4,d4] = dwt(a3,wname);
[a5,d5] = dwt(a4,wname);

% Inverse DWT
a5_ = (abs(a5)>a5thresh).*a5;
d5_ = (abs(d5)>d5thresh).*d5;
a4t = idwt(a5_,d5_,wname);
a4_ = (abs(a4t)>a4thresh).*a4t;
d4_ = (abs(d4)>d4thresh).*d4;
a3t = idwt(a4_,d4_,wname);
a3_ = (abs(a3t)>a3thresh).*a3t;
d3_ = (abs(d3)>d3thresh).*d3;
a2t = idwt(a3_,d3_,wname);
a2_ = (abs(a2t)>a2thresh).*a2t;
d2_ = (abs(d2)>d2thresh).*d2;
a1t = idwt(a2_,d2_,wname);
a1_ = (abs(a1t)>a1thresh).*a1t;
d1_ = (abs(d1)>d1thresh).*d1;
x_ = idwt(a1_,d1_,wname);

% Output
figure;
subplot(221); stem(a5); title('a5','fontsize',14);
subplot(222); stem(d5); title('d5','fontsize',14);
subplot(223); stem(a5_); title('a5 filtered','fontsize',14);
subplot(224); stem(d5_); title('d5 filtered','fontsize',14);
figure;
subplot(221); stem(a4); title('a4','fontsize',14);
subplot(222); stem(d4); title('d4','fontsize',14);
subplot(223); stem(a4_); title('a4 filtered','fontsize',14);
subplot(224); stem(d4_); title('d4 filtered','fontsize',14);
figure;
subplot(221); stem(a3); title('a3','fontsize',14);
subplot(222); stem(d3); title('d3','fontsize',14);
subplot(223); stem(a3_); title('a3 filtered','fontsize',14);
subplot(224); stem(d3_); title('d3 filtered','fontsize',14);
```

```
figure;
subplot(221); stem(a2); title('a2','fontsize',14);
subplot(222); stem(d2); title('d2','fontsize',14);
subplot(223); stem(a2_); title('a2 filtered','fontsize',14);
subplot(224); stem(d2_); title('d2 filtered','fontsize',14);
figure;
subplot(221); stem(a1); title('a1','fontsize',14);
subplot(222); stem(d1); title('d1','fontsize',14);
subplot(223); stem(a1_); title('a1 filtered','fontsize',14);
subplot(224); stem(d1_); title('d1 filtered','fontsize',14);

E = norm(x_ - xorig)/norm(xorig)*100;

disp(['Percent Relative Error: ', num2str(E)]);


soundsc(x_,fs);
```

The code I ran with the given parameters gave around a 7.6 error percentage.






a3
d3
a3 filtered
d3 filtered
a4
d4
a4 filtered
d4 filtered
a5
d5
a5 filtered
d5 filtered