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FILTERING ECG SIGNAL

SIGNAL PROCESSING PROJECT #2

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THE SOURCE CODE

```
filename = 'noisy_ecg.mat';
myVars = {'Ts','ecg','fs'};
S = load(filename,myVars{:});

Ts=0.002;
fs=1/Ts;
wm=pi*fs;

wc=2*pi*(40/fs);

n=-30:30;
h=sinc(wc*n/pi)*wc/pi;

figure(1)

t=0:Ts:9.998;
subplot(3,1,1)
plot(t,S.ecg);
xlabel('Time');
ylabel('Amplitude');

y=filtfilt(h,1,S.ecg);
subplot(3,1,2);
plot(t,y);
xlabel('Time');
ylabel('Amplitude');

a=filter(h,1,S.ecg);
subplot(3,1,3);
plot(t,a);
xlabel('Time');
ylabel('Amplitude');


figure(2)

imp = [1; zeros(180,1)];
impresponse_filter=filter(h,1,imp);
b=stem(0:180,impresponse_filter);
xlabel('Samples');
ylabel('Amplitude');

figure(3)

freqz(h);
```

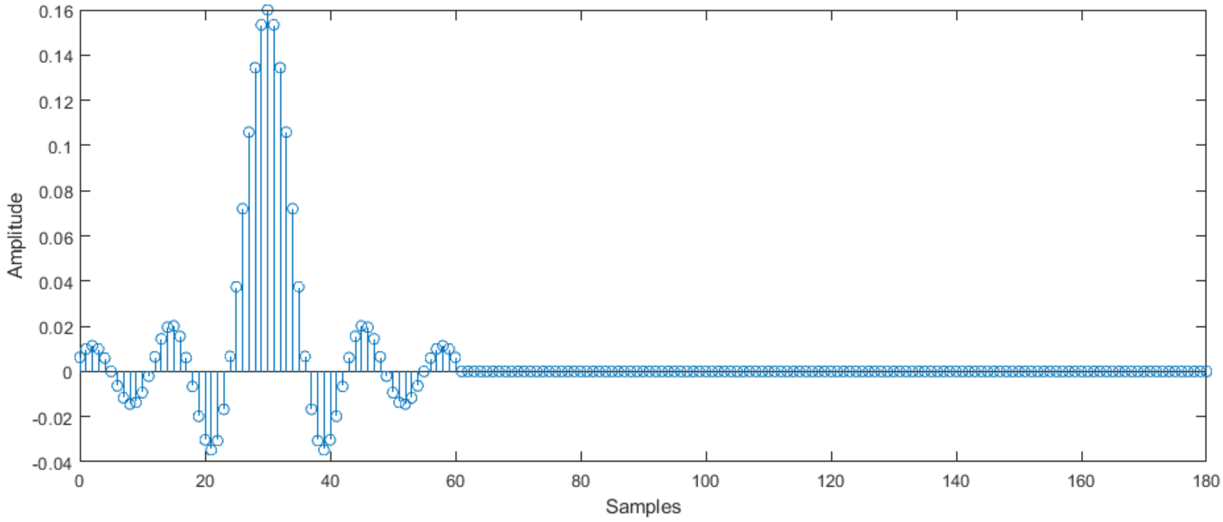
THE FILTER COEFFICIENTS

We can get the filter coefficients from the impulse response matrix' elements. We can obtain them as;

a(0) = 0.0062366
a(1) = 0.00993157
a(2) = 0.0113458
a(3) = 0.009954
a(4) = 0.00589796
a(5) = 3.89975e-17
a(6) = -0.00638946
a(7) = -0.0116851
a(8) = -0.0144401
a(9) = -0.013715
a(10) = -0.00935489
a(11) = -0.00209973
a(12) = 0.00650987
a(13) = 0.0144272
a(14) = 0.019542
a(15) = 0.020182
a(16) = 0.0155642
a(17) = 0.00608927
a(18) = -0.0065967
a(19) = -0.0198089
a(20) = -0.0302731
a(21) = -0.0347413
a(22) = -0.0306577
a(23) = -0.0167397
a(24) = 0.00664913
a(25) = 0.0374196
a(26) = 0.0720038
a(27) = 0.105894
a(28) = 0.134379
a(29) = 0.153347
a(30) = 0.16

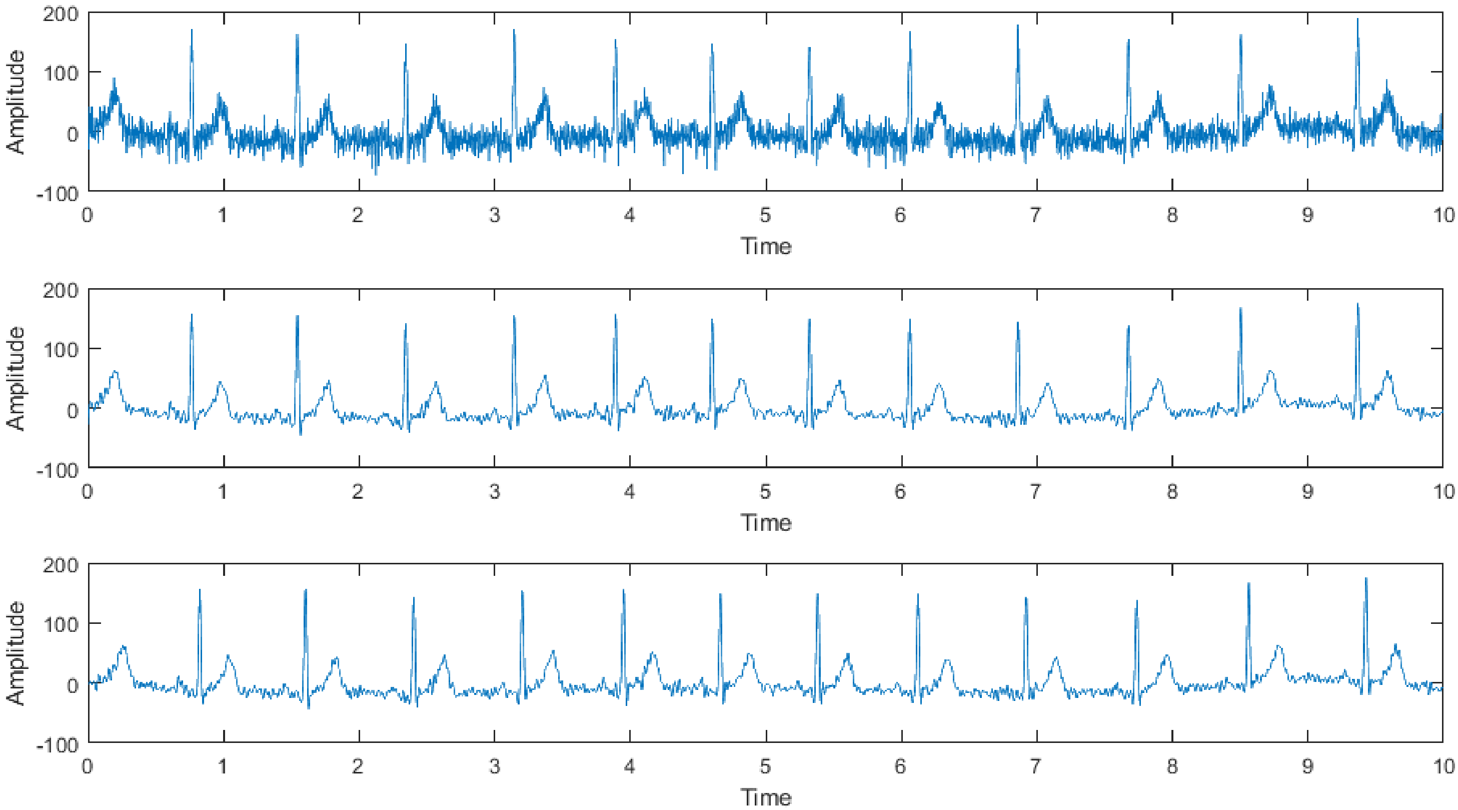
a(31) = 0.153347
a(32) = 0.134379
a(33) = 0.105894
a(34) = 0.0720038
a(35) = 0.0374196
a(36) = 0.00664913
a(37) = -0.0167397
a(38) = -0.0306577
a(39) = -0.0347413
a(40) = -0.0302731
a(41) = -0.0198089
a(42) = -0.0065967
a(43) = 0.00608927
a(44) = 0.0155642
a(45) = 0.020182
a(46) = 0.019542
a(47) = 0.0144272
a(48) = 0.00650987
a(49) = -0.00209973
a(50) = -0.00935489
a(51) = -0.013715
a(52) = -0.0144401
a(53) = -0.0116851
a(54) = -0.00638946
a(55) = 3.89975e-17
a(56) = 0.00589796
a(57) = 0.009954
a(58) = 0.0113458
a(59) = 0.00993157
a(60) = 0.0062366

THE IMPULSE RESPONSE



FILTERING THE NOISE

The graphs are noisy signal, filtered signal with *filter*, filtered signal with *filtfilt*, respectively.



Filtfilt commands execute a zero-phase filtering when filter command execute normal filtering. Zero-phase filtering can be used for avoiding phase distortion, it's a noncasual filter. So it can be used for post-processing of stored data, like this ECG signal.

As we can see, the signal filtered with filtfilt command starts around zero amplitude. We can define the zero-phase filtering algorithm as follows;

- ***Filter the signal – Time reverse the signal – Filter the signal – Time reverse the signal***

MAGNITUDE OF THE FREQUENCY SPECTRUM