

FILTERING OF ECG SIGNAL USING BUTTERWORTH FILTER AND ITS FEATURE EXTRACTION

BHARTI SALSEKAR

Electrical Engineering Department
M.I.T.S. Gwalior, M.P., INDIA
bhartisalsekar01@gmail.com

DR. A. K. WADHWANI

Professor, Electrical Engineering Department
M.I.T.S. Gwalior, M.P., INDIA
wadhvani_arun@rediffmail.com

Abstract:

This paper represents filtering of ECG signal of a healthy person and also an unhealthy person using Butterworth filter and then we extract the features of the resultant noise free ECG signals. The analysis of ECG can benefit from the wide availability of computing technology as far as features and performance as well. The overall process has been subdivided into the process of filtering and then its feature extraction using MATLAB. The features of both the ECG signals are calculated and by comparing these results together we can find the abnormalities in the heart of the unhealthy person. The features calculated are: amplitude of P wave, amplitude of R wave, amplitude of T wave, RR interval etc.

Keywords— ECG, Butterworth filter, feature extraction.

1. Introduction:

The Electrocardiogram (ECG) is an important bio-electrical signal, used by the cardiologist to diagnose various diseases and conditions associated with the heart and the state of the cardiac system. ECG is a test that measures electrical activity of the heart with the help of electrodes placed on the surface of the body. The ECG is a graphic recording or display of time variant voltages produced by the myocardium during the cardiac cycle.

For the diagnosis a cardiologist also looks at the heart rate. The normal value of heart rate of an adult person lies in the range of 60 to 100 beats per minute (BPM).

2. Formation of ECG waveform:

The ECG wave contains P wave, QRS complex and T wave. These waves generated by the depolarisation and repolarisation of atria and ventricles. Figure (1) shows the basic waveform of an ECG signal.

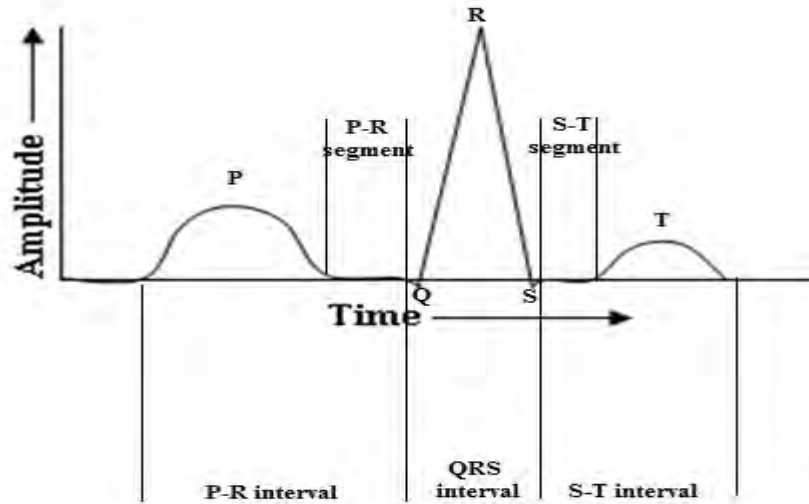


Figure 1. ECG Waveform

The ECG wave forms in the following manner:

P wave: represents atria depolarisation.

QRS complex: represents ventricular depolarisation.

T wave: represents ventricular repolarisation.

Some normal values for amplitude and duration of an ECG parameter are shown in Table 1 and Table 2 respectively.

TABLE 1

NORMAL VALUES OF ECG FOR AMPLITUDE

P wave	0.25 mV
R wave	1.60 mV
Q wave	25% of R wave
T wave	0.1 to 0.5 mV

TABLE 2

NORMAL VALUES OF ECG FOR DURATION

P-R interval	0.12 to 0.20 sec
Q-T interval	0.35 to 0.44 sec
S-T segment	0.05 to 0.15 sec
P wave interval	0.11 sec
QRS interval	0.09 sec

3. Pre-processing:

Generally, the presence of noise will corrupt the signal, and make the feature extraction and classification less accurate. Preprocessing involves removal of noise from input ECG signal. The pre-processing contains 4 stages:

- ECG data recording: The ECG data recorded using ECG electrodes. Generally 10 electrodes are placed on the human body. These electrodes are: v1 to v6 (for chest), RA (Right Arm), LA (Left Arm), RL (Right Leg), LL (Left Leg).

The ECG data, I am taken from the website <http://www.physionet.org/cgi-bin/atm/ATM>

- Filtering of ECG signal: Filtering of any signal is done to remove any type of noise or distortion present in the signal. Here we are using Butterworth low pass filter to remove the noise. We are not using the Butterworth high pass filter because it creates more distortion in our signal after applying it.

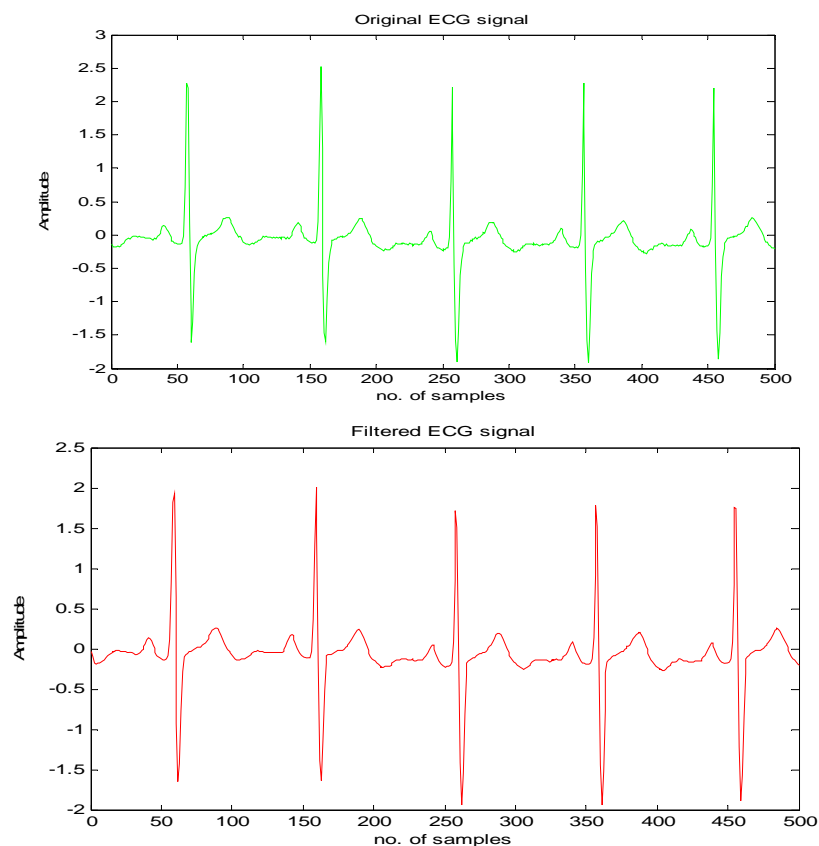
A Butterworth low pass filter is designed using

$$[B,A]=\text{butter}(n, w_n)$$

Where n =order of the filter and w_n =cut-off frequency (must be between 0 and 1)

B (numerator) and A (denominator) are the filter coefficients of length $n+1$.

Figure (2) shows the filtering process of ECG signal of healthy person using Butterworth filter. It contains 500 samples.



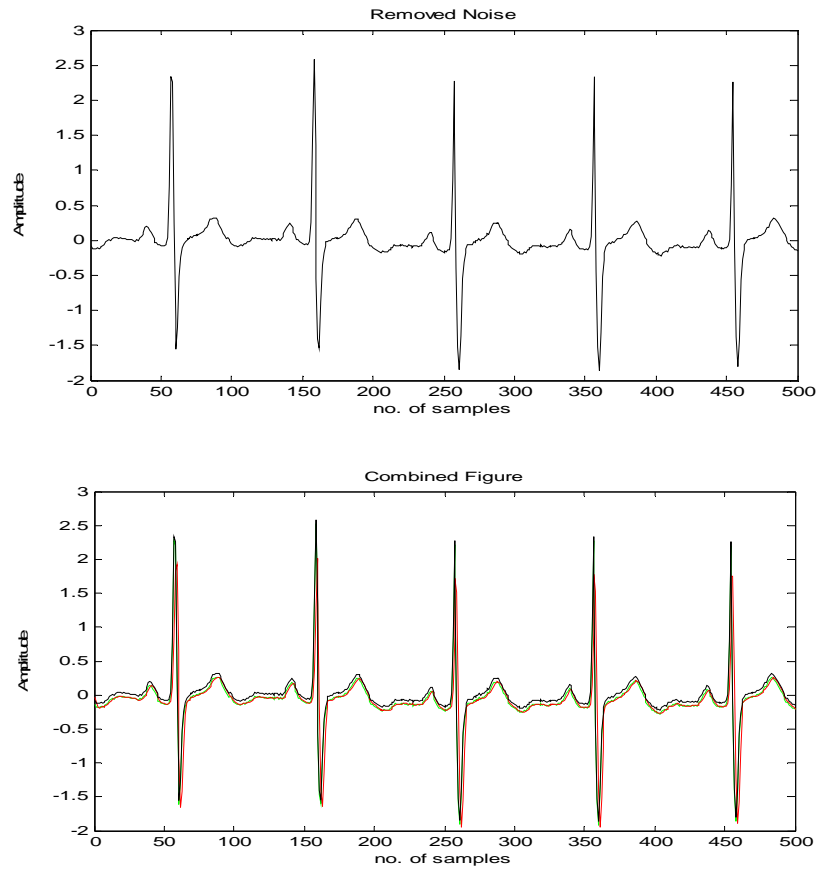
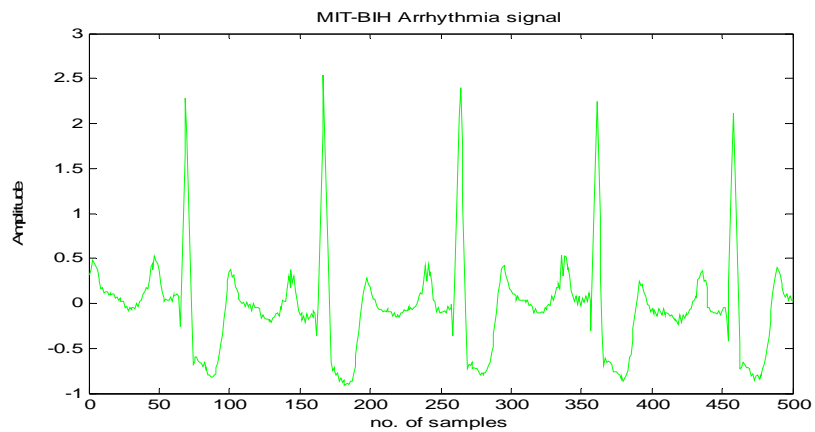


Figure 2. Filtering process of ECG Signal (Subject 1)

Figure (3) shows the filtering process of MIT-BIH Arrhythmia signal. It also contains 500 samples.



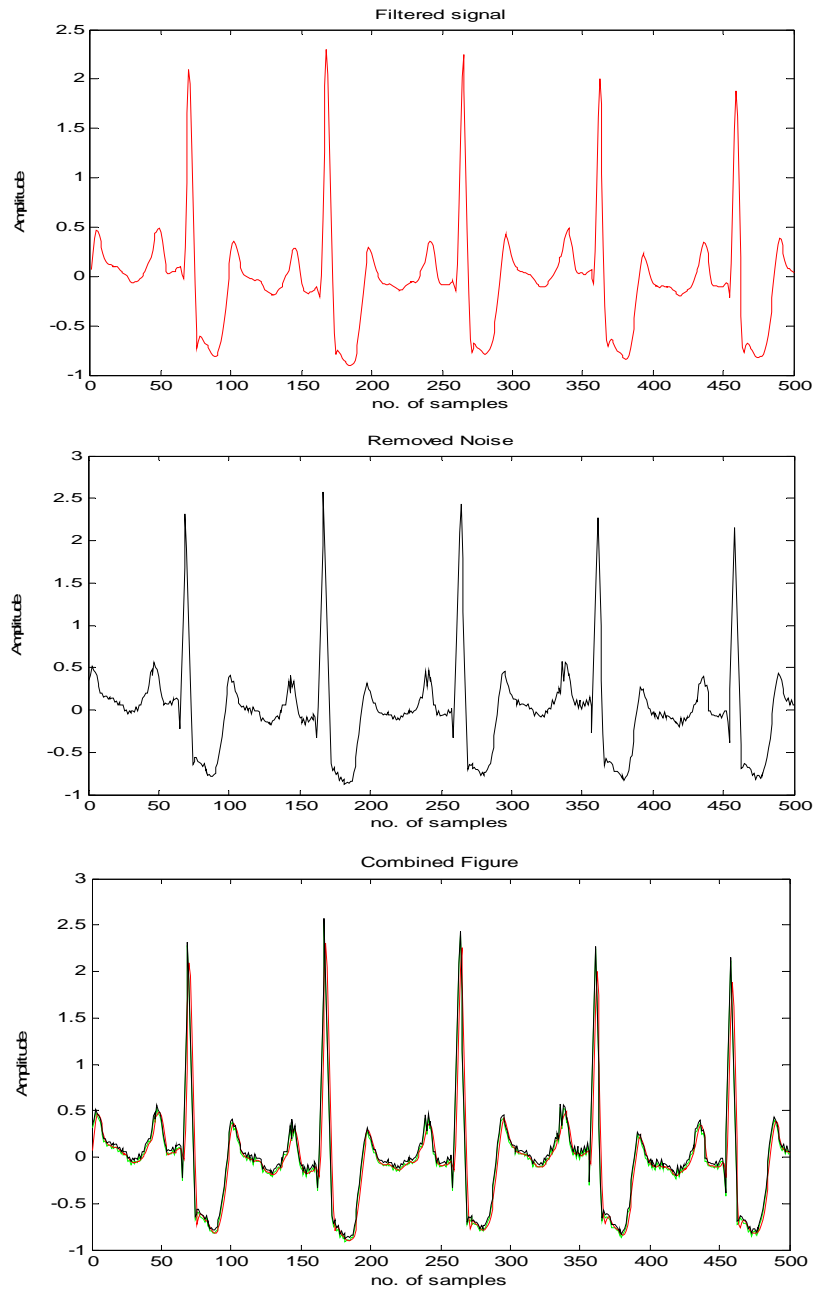


Figure 3. Filtering process of MIT-BIH Arrhythmia Database (Subject 2)

• Feature extraction: Clinically important features of an ECG signal for disease diagnosis are: P wave amplitude, R wave amplitude, T wave amplitude, RR interval etc. The disease diagnosis is based on the calculation of these parameters.

These features are extracted by using MATLAB programming. These results are shown in Table 3.

TABLE 3
RESULTS OF FEATURE EXTRACTION

	R wave Amplitude	P wave Amplitude	T wave Amplitude	RR Interval
Subject 1	1.72	0.2178	0.2532	0.5838
	1.87	0.2302	0.2429	0.5723
	1.68	0.2080	0.1911	0.5723
	1.70	0.2088	0.2118	0.5665
	1.69	0.2000	0.2518	
Results	Normal	Normal	Normal	Normal
Subject 2	2.093	0.4843	0.3605	0.4665
	2.301	0.3074	0.2934	0.4358
	2.252	0.3554	0.4219	0.4491
	2.105	0.4866	0.2304	0.4558
	2.000	0.3522	0.3825	
Results	Abnormal	Abnormal	Normal	Abnormal

4. Results and Discussions:

According to our analysis for subject 1 following results were obtained:

- R wave amplitude varies between 1.68 to 1.97 (normal). The average value is 1.72.
- P wave amplitude varies between 0.20 to 0.23 (normal). The average value is 0.22.
- T wave amplitude varies between 0.1911 to 0.2532 (normal). The average value is 0.23.
- RR interval varies between 0.5665 to 0.5838 (normal). The average value is 0.58 sec.

Similarly according to our analysis for subject 2 following results were obtained:

- R wave amplitude varies between 2 to 2.301 (abnormal). The average value is 2.15.
- P wave amplitude varies between 0.3074 to 0.4866 (abnormal). The average value is 0.4.

In severe hypokalemia, an increase in amplitude of the P wave, prolongation of the PR interval, and widening of the QRS complex may all occur. And a decrease in P wave amplitude sometimes followed second-degree or third-degree AV block.

- T wave amplitude varies between 0.2304 to 0.4219 (normal). The average value is 0.34.
- RR interval varies between 0.4358 to 0.4665 (abnormal). The average value is 0.45 sec.

5. Conclusions:

This method is easy and suitable to find all intervals and amplitudes of ECG waveforms. The Butterworth filter used, effectively remove noise from the corrupted ECG signal. After finding out all the features and comparing it with the standard values we can decide that the person is normal or abnormal. A MATLAB based analytical method for feature extraction and disease diagnosis is used.

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