

An Efficient Method for DE-Noising Signal And A Unique Feature Extraction Algorithm

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Abstract— Numerous researches are going on Electrocardiogram and its feature extraction. Feature Extraction from the ECG is the main focus of the researches. There are many classification of the ECG signal which helps doctors to identify many problems related to the heart and also other parts of body. In this paper we are presenting a method for De-noising of ECG signal and Feature extraction Algorithm. We considered the base line problem in ECG signal which is basically due to the measurement error. In this work with the help of IIR filter Savitzky-Golay filter and Wavelet Transform we de-noise the ECG signal without affecting any information from ECG. We also design a feature Extraction algorithm which automatically detects the RR interval and QRS interval along with the amplitude of Q, R, and S. The whole algorithm including the de-noising of signal and Feature extraction was developed on the MATLAB platform. Program was tested on Recorded ECG signal from Physiobank database as a proof efficacy of our work.

Keywords—Base Line wander, RR-interval, QRS detection, ECG Wavelet

I. INTRODUCTION

Electrocardiography is becoming spirit of a doctor and this will be not wrong if we said that it is also the spirit of the patients. There are numerous researches held on the ECG and also many real time projects. ECG signal is basically a recorded potential differences between the body parts. Pumping of heart is responsible for that potential differences. Due to the contraction and relaxation of heart there is a potential generated which is represented as ECG signal. There also many researches are done on the ECG recording and its sensors. Present sensors for the ECG signal are very accurate and developed with the high quality material and optimized spatially for human body. ECG or EKG sensor are just like an electrode which measure the potential developed due to action or resting potential. Resting potential and action potential generated over the chest surface during cardiac cycle.

Standard ECG signal contains P, Q, R, S and T peaks which contains the information or heart. The amplitude and interval between the peaks are used to identify many diseases. For example RR interval gives the information about the hypertension, bradycardia, tachycardia and other diseases. Latest research shows that RR interval also gives the information about the mind. One paper is published on the stress level measurements in which author shows that taking statical parameters gives information about the stress. ECG was recorded during the driving condition. A neural network designed for testing the results and surprisingly designed system was able to tell the stress level. Similarly QRS interval also gives many information about the diseases related to heart.

In the present work we designed a software which can be used with real time recording system and also for database separately. The software is developed in Matlab environment using the wavelet, DSP and basic Matlab toolbox. By the help of the wavelet and infinite impulse response filter we have able to de-noise the signal and Savitzky-Golay filter smoothen the signal. The software which we designed also have feature extraction characteristic which identifies the Q, R, and S peaks and gives RR interval and QRS interval.

II. METHODS

2.1 De-Noising of ECG signal

The ECG signal is downloaded from the physiobank on which we tested our algorithm. The recorded signal contains lots measurement noise and also white noise. Main problem with the physiobank data is that they contain base line wander problem. The base line wander is a low frequency signal on the whole signal careered on the low noise signal and this makes difficulty for the peak detection because the whole signal is sifted from the original base line. For example the recorded signal with base line wander problem is given in figure 1.

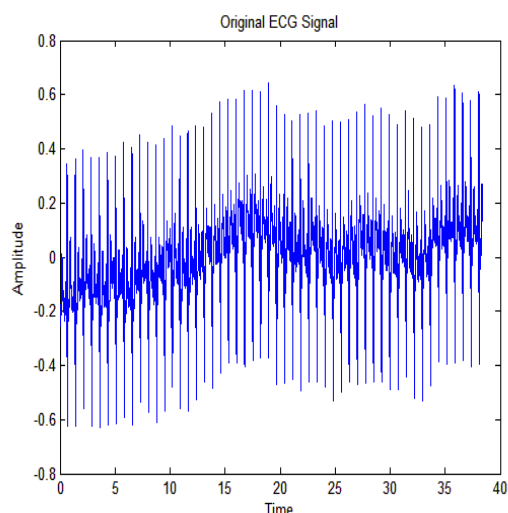


FIG 1: ORIGINALLY RECORDED ECG SIGNAL
 THE BASE LINE SIGNAL CONTAINS THE FREQUENCY LESS THAN 1HZ TYPICALLY 0.5 HZ. SO FOR REMOVING THE BASE LINE WANDER FROM THE SIGNAL WE DESIGNED AN IIR BUTTERWORTH HIGH PASS FILTER WITH THE CUTOFF FREQUENCY OF 1 HZ AND THE SAMPLING FREQUENCY IS AS SAME AS OF THE ECG SIGNAL RECORDING FREQUENCY. OTHER DISTURBANCE FROM THE SIGNAL IS BEEN REMOVED BY THE WAVELET TRANSFORM [1]. WE USED 'DB4' MOTHER WAVELET AND IT GIVES BEST RESULT ESPECIALLY ON ECG SIGNAL [2]. BY USING THE 3 LEVEL DECOMPOSITION OF SIGNAL WE ARE ABLE TO REMOVE ALMOST ALL HIGH FREQUENCY NOISE. AND FINALLY SAVITZKY-GOLAY FILTER SMOOTH THE ECG SIGNAL AND GIVES US THE CLEANEST ECG SIGNAL

2.2 Feature extraction Algorithm

Feature extraction algorithm is used to detect here the Q, R and S peaks of signal and for finding out the RR interval and QRS interval [12]. For which the algorithm is given in figure 2. According to the algorithm we found first R peaks from the signal because that is easiest point to detect and also the R peak is center of the ECG signal. Inbuilt Matlab function 'findpeaks' is available for peak detection. This function gives the all the peaks which is greater than the threshold value and we can also set minimum interval between peaks. And by this operation we will have the R-peak amplitude and the respective time of the peak .

The similar operation is applied on the signal again for finding the S-peak. The S-peaks is the highest negative amplitude peak which can be easily detected by the above process if we invert the signa.

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While (1)

    {

        a. Load ECG signal;
        b. Pass the Signal with High Pass Filter for removing of base line wander. (with cutoff frequency 1Hz);
        c. Apply Wavelet Transform and find approximation Coefficient;
        d. Apply Savitzky-Golay Filter;
        e. R_data=Find R peaks with threshold 0.3 V;
           For i=length (R_data)

               {

                   RR_interval(i)=R_data(i+1)-R_data(i); }

           End

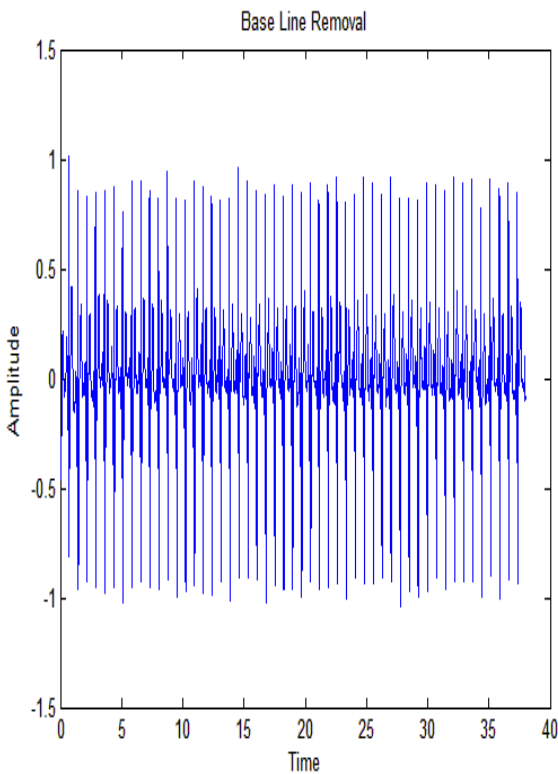
        f. RR_interval_mean=Mean(RR_interval);
        g. QS_data=Invert The signal and find peaks Q and S peaks
        h. Q=Odd index element of QS_data;
        i. S=Even index of element of QS_data;
        j. Find QRS interval mean;
    }

end
  
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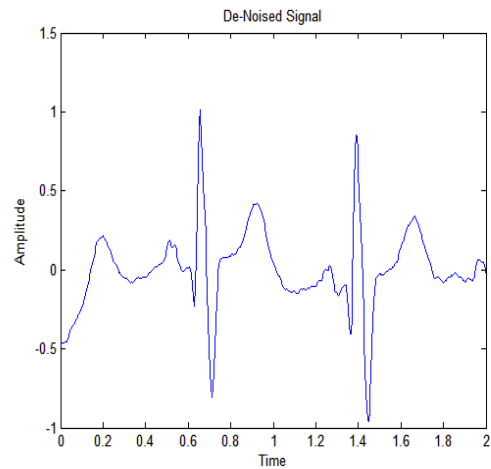
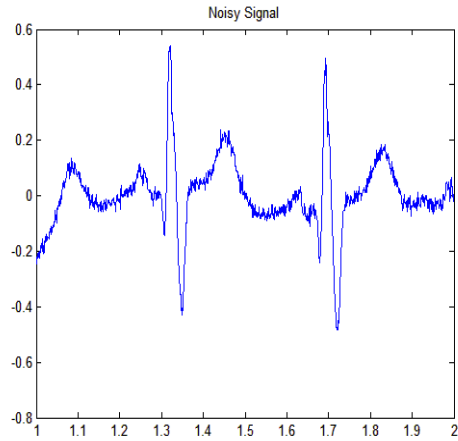
When we invert the signal we will have highest positive peaks which will now the S-peak. After this we will have inverted amplitude of the S-peak and time location of that peak. Detecting Q peak is much more difficult and will become more difficult, when the signal is noisy. So for detection of Q peak we have to first clean the signal as much as possible. The Q peak also detected with the inverted signal because 'findpeaks' function find the max peaks. For detecting the Q peak we set minimum peak height as 0.2V. Now we will have Q peak and S peak also which will store in an array. The odd number of elements will be the Q peaks and even number of peaks will be the S peaks. And hence we will able to detect QRS peaks and its amplitude.

III. RESULTS

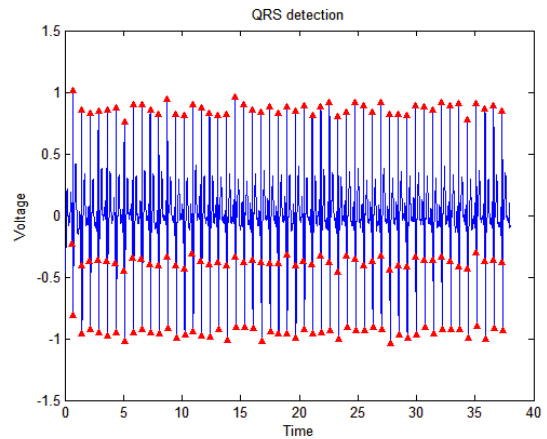
Designed software has been tested on the Physiobank database. The data was download from the physionet site in the '.mat' format. The '.mat' format can be loaded in the Matlab directly by a simple 'load' command. The database contains not only ECG signal but also other signals like EMG, EEG and respiratory level etc. Among of those data we extract the ECG signal with proper array operation in MATLAB. The data as already explained contains base line wander problem due to which signal amplitude changes over time. For removing this low frequency signal we design a butterworth high pass IIR filter with the cutoff of 1Hz and we get following signal (figure 3) which is free from base line wander problem.

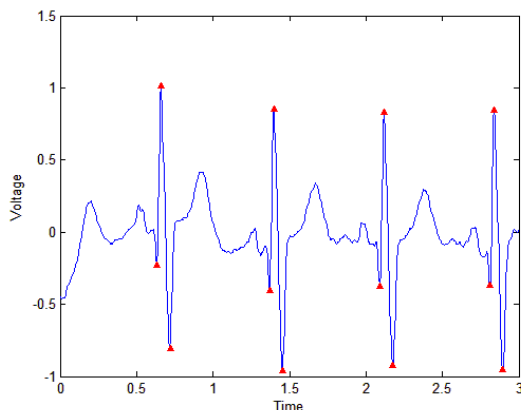


The signal is then de-noise using the Wavelet transform and smoothing is done by the Savitzky-Golay filter. The original signal and the de-noised signal is given in the figure 4. The signal shown in this figure is the part of the signal which is given in figure 3. Figure 3 signal shows the data for the 38 sec and figure 3 data is of 2 sec, this will give better comparison between these signals.



Finally we applied the Feature Extraction algorithm for QRS detection and calculating the QRS interval and RR interval. We plot the detected peak with marker for result explanation given in figure 5. We used 's0010_rem' data for the algorithm testing and we found accurate results. QRS detection waveform is given with all 38 sec signal and for better view another waveform is given in figure 5 with 3 sec. For particularly with this signal we found 0.732903 sec mean RR interval and 0.0847913 sec mean QRS interval.





IV. Conclusion

Thus such a implementation serves as an initiative to wards the development of a computerize diagnosis system. future there are other provision to convert the matlab programs to embedded c program matlab implementation of ECG signal processing that tries to exhibit an increased performance over the hardware implementation of the same. To add these systematic approaches are in the way of their progress in the field of present day medicine like biotelemetry etc.

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