

3.2 ECG Baseline Drift Removal

Since the low frequency components cause the signal for baseline shifting, these components must be deducted to have a signal without baseline drift. In this study, the low frequency components of a decomposed signal are A8 and D8. Therefore, to remove the baseline drift, the developed algorithm removes these components from the original ECG signal. Thus, the problem of baseline shifting is solved. The original and detrended ECG signal of length 800 samples is shown figure7.

3.3 ECG De-noising

Though the low frequency components are removed from the original signal, still it may have noise due to high frequency components. In order to remove the noise from ECG signal, it is required to identify which components contain the noise and then these identified components are removed from the detrended signal. When a signal is decompose by DWT, the successive approximations becomes less and less noisy as more and more high frequency information is filtered out of the signal. But, in discarding all the high frequency information many of the original signal's sharpest features are lost. Optimal de-noising requires a more subtle approach called *thresholding* [12]. This involves discarding only the portions of the details that exceed a certain limit.

The developed algorithm uses global thresholding option, which is derived from Donoho-Johnstone fixed form thresholding strategy for an un-scaled white noise. By using the developed algorithm, the identified high frequency components are D1, D2. These components must be filtered by applying a threshold. Then the thresholded components are removed from the de-trended signal.

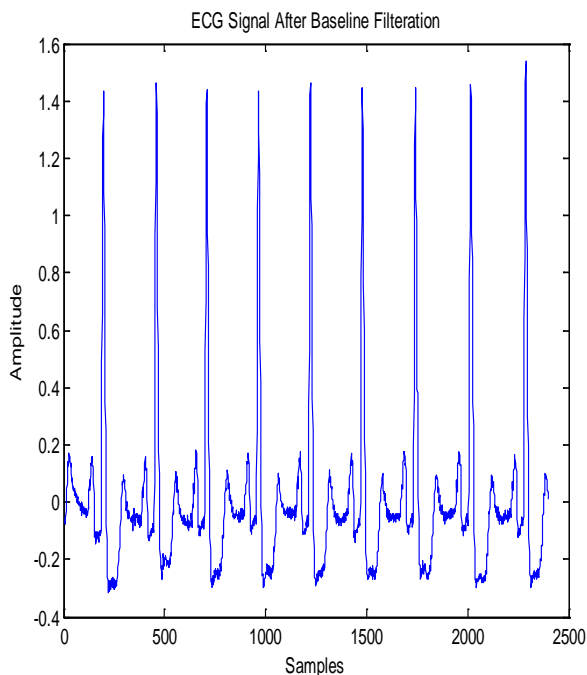


Figure 7: The De-trended ECG Signal

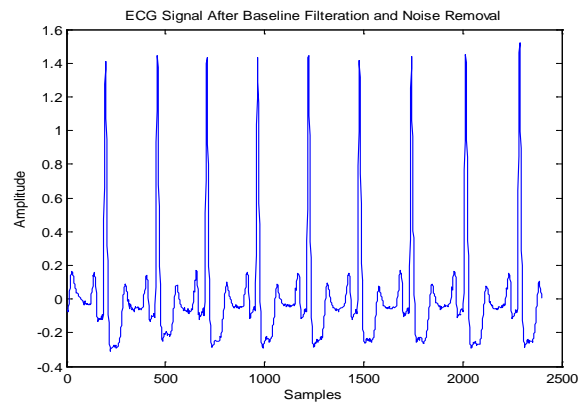


Figure 8: De-noised ECG signal

The denoised ECG signal of length 800 samples is shown in figure 8.

3.4 Extraction of ECG Features QRS complex

Since the peaks of R waves in the ECG signal have the largest amplitude values among the other waves, identifying the QRS complexes of an ECG signal by using the developed algorithm is an easy task. To detect the R waves, the developed algorithm removes the very low and very high frequency components from the ECG signal. In this study, the detail components of D3, D4 and D5 show the QRS complex more clearly comparing with other components. Therefore, the algorithm keeps these components and removes the other low frequency and high frequency components. The R waves of ECG signals are shown in figure 9.

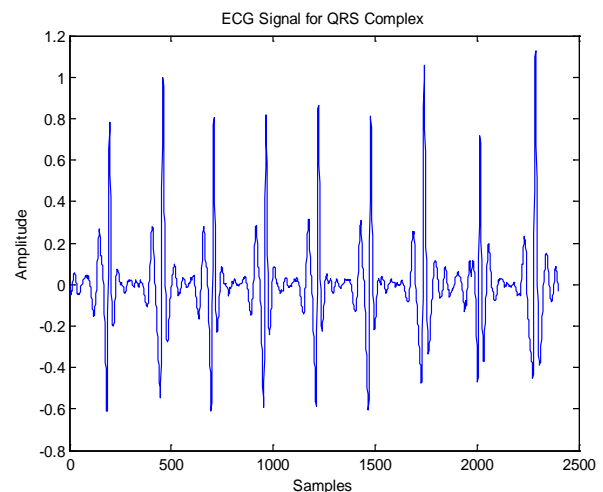


Figure 9: R-waves of the ECG Signal

3.5 R Waves of the ECG Signal

To make the R wave more noticeable, the obtained signal is squared, which is shown in figure 10. Since the obtained signal has pseudo peaks, a lower limit is applied to remove these pseudo peaks (thresholding), which is shown in figure 11. Once the R-peaks are identified then it can be used by the developed algorithm to automatically calculate the amplitude values of R waves and the time intervals between them.

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signal has pseudo peaks, a lower limit is applied to remove these pseudo peaks (thresholding), which is shown in figure 11. Once the R-peaks are identified then it can be used by the developed algorithm to automatically calculate the amplitude values of R waves and the time intervals between them. The amplitude values of R waves for ECG record 105 of arrhythmia, determined by the developed algorithm.

Once the R peaks are determined then based on these peaks the Q and S peaks are detected. Generally, the Q and S peaks occurs about the R peak within 0.1 second. Therefore, to make the peaks more noticeable, the developed algorithm removes all the detail components of the signal up to D5 from the signal. The approximation signal is remained same. The first negative deflection to the left of the R-peak is denoted as Q-peak and the first negative deflection to the right of the R peak is denoted as S peak. In the figure 12, the left point about the R peak denotes the Q-peak and the right point about the R peak denotes the S peak. Once the R-peaks are identified then it can be used by the developed algorithm to calculate the amplitude values of Q and S waves automatically.

3.6 P and T-waves

The extreme of the signal before and after zero crossings about QRS complex denotes the P and T waves. The detected zero crossings of the signal about the P and T peaks are the onset and offset points of the waves respectively. To make the P and T peaks more noticeable, the developed algorithm keeps the details D4 to D8, which are shown in figure 13. Once the

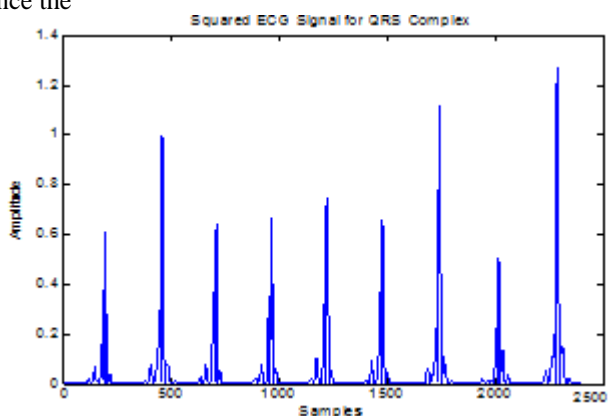


Figure 10: The Power of R-waves of the ECG Signal

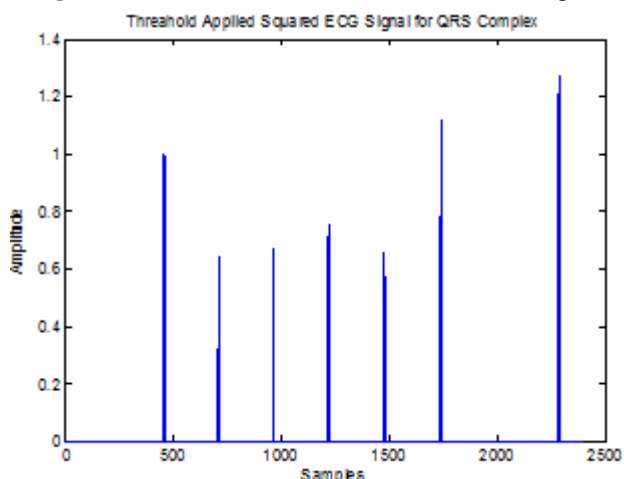


Figure 11: Thresholded R-waves of the ECG Signal

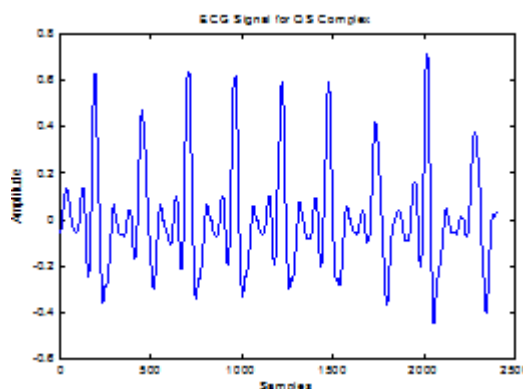


Figure 12: The Q and S-waves of the ECG Signal

P and Q peaks are identified then it can be used by the developed algorithm to calculate the amplitude values of P and T waves automatically

3.7 RR-Interval

The R-R interval of an ECG signal is the time interval between the R-waves. In order to determine the R-R interval of a signal, the developed algorithm determines the difference between the two consecutive R wave locations based on the identified R waves. Since these interval values are not constant throughout the signal, it indicates the abnormality of a heart rate. Also the number of heart beats per minute calculated (number of R-R intervals) by the developed algorithm is 60.

3.8 The P and T waves of the ECG Signal

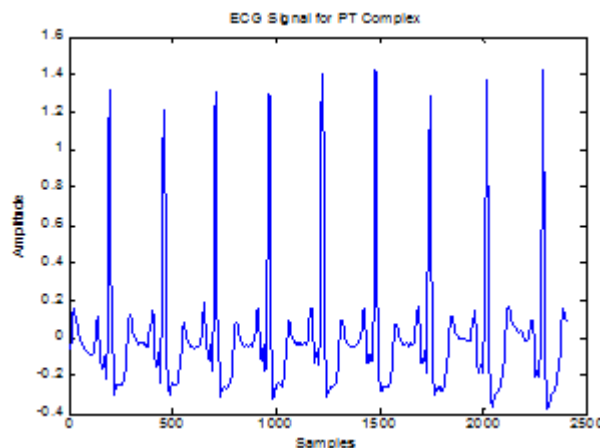


Figure 13: The P and T waves of ECG Signal

a)P-R Interval

Once the P and R waves are identified, it can be used by the developed algorithm to determine P-R intervals. In order to determine P-R interval, the developed algorithm determines the interval between the onset of P waves and onset of Q waves.

b)S-T Interval

Once the S and T waves are identified, it can be used by the developed algorithm to determine S-T intervals. In order to determine S-T interval, the developed algorithm determines the interval between the onset of S waves and offset of T waves

c) Q-T Interval

Once the Q and T waves are identified, it can be used by the developed algorithm to determine Q-T intervals. In order to determine Q-T interval, the developed algorithm determines the interval between the onset of Q waves and offset of T waves.

In above feature extraction use threshold values for the accuracy of the signal this proposed methodology is use by us to denoising and de trending the signal.

4. Conclusion

As the abnormality of heart beat can be showing up at any interval of ECG signal, it is difficult to physicians for manually analyze and to extract the features and also it is a time consuming process. Therefore, the proposed developed algorithm can be used to automatically extract features from ECG signal which increases the accuracy and reduces the time. Thus the performance of the proposed algorithm is increased.

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