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Analysis Method on Extraction of R-peak Feature in ECG Signal for Discrimination between Normal and Abnormal Heart Conditions

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Abstract: Diagnosis of the heart condition is essential to detect the problems related to the heart and blood vessels. Normally, a physical examination and blood test could be performed besides the electrocardiogram (ECG) test. However, most of the ECG test is later be analyzed in the time domain only which unable to access further information. Therefore, this work aims to extract the ECG features in both time and frequency domains that are able to distinguish between normal and abnormal conditions. The R-peak is semi-automatically extracted in both normal and abnormal ECG signal. The undetected and misleading R-peak in abnormal ECG signals is then analyzed using Wavelet Decomposition by down-sampling the signal with variable Daubechies values. The results show that the undetected R-peak in abnormal ECG signals is able to be indicated rhythmically in each heart cycle.

Keywords: Electrocardiogram (ECG), Wavelet Decomposition, R-peak, QRS Complex

1. Introduction

Recently, heart disease has become ever more common in Malaysia. It shows that heart attacks are now a common occurrence among Malaysians in their 20s and 30s [1]. This fact motivates people to prevent it and find the best treatment for heart disease. The conventional procedures in the diagnosis of heart disease are based on the patient's medical history, the outcomes of physical exams, and the occurrence of the symptoms that might be connected to the medical doctors. Those methods, however, often lead to the producibility problem due to the operator-dependent technique. Moreover, the diagnosis machines are costly to be operated and required much time to produce the results [2]. Here, researchers made several efforts to create noninvasive smart healthcare systems in overcoming those problems [3]. The depth analysis of electrocardiogram (ECG) signal has become one of the mediums for the prediction of diagnosis of heart disease using Artificial Intelligent (AI) concepts such as machine

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learning [4] and [5]. This is due to the simplicity of the signal that indicates directly the electrical process that occurs in the heart. Moreover, the acquisition of ECG signal itself is a non-invasive technique that always gives comfort to patients. Thus, this work proposes to diagnose the heart condition utilizing the ECG signal in both time and frequency domains that are expected to be able to overcome the problem of undetected features in abnormal ECG signals.

2. Methodology

2.1 Initial Data Collection and Analysis

The ECG signals were initially collected from Physionet website. The signals are then divided into two groups: normal and abnormal based on the provided folder. Figure 1 shows the flow used in this proposed work in detecting the ECG feature or R-peak.

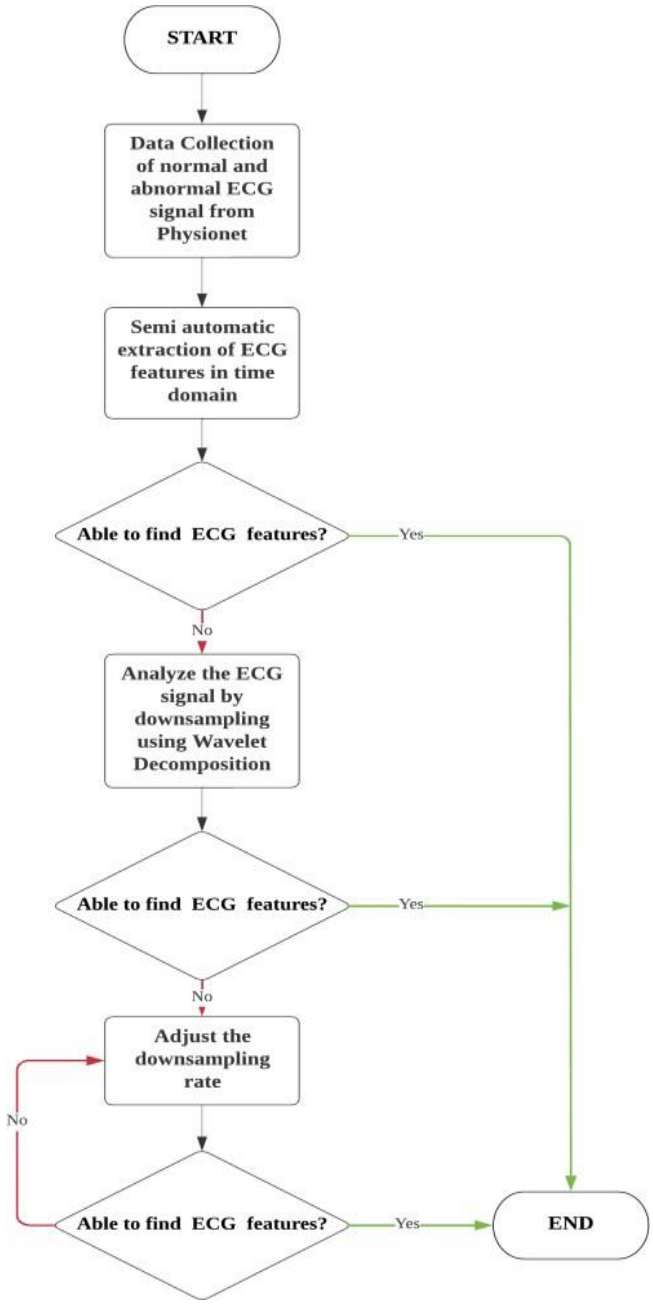

Figure 1: Workflow in detecting the ECG feature

At first, the normal ECG signal is analyzed by finding the R-peak in 11 s duration of the signal (Figure 2). The peak was easily detected even with manual technique. The peak however is detected semi-automatically by setting up the rhythm of time duration for each cycle. MATLAB software was used during the analysis. The next feature of the QRS complex is later extracted as shown in Figure 3. The QRS complex range can be determined from the first trigger point prior to the R-peak until the next trigger point after the R-peak is located.

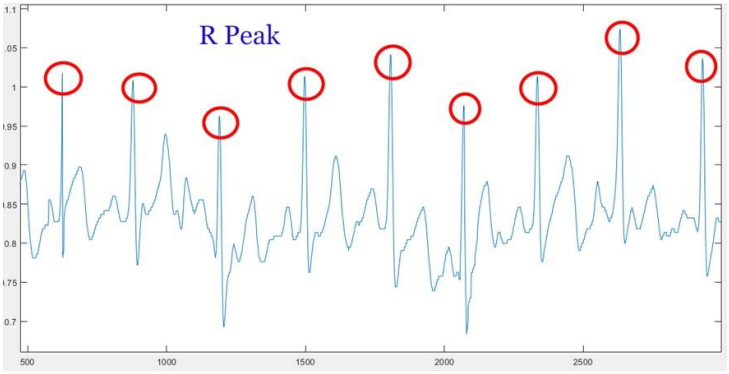

Figure 2: Indicating of R-peak in normal ECG signal

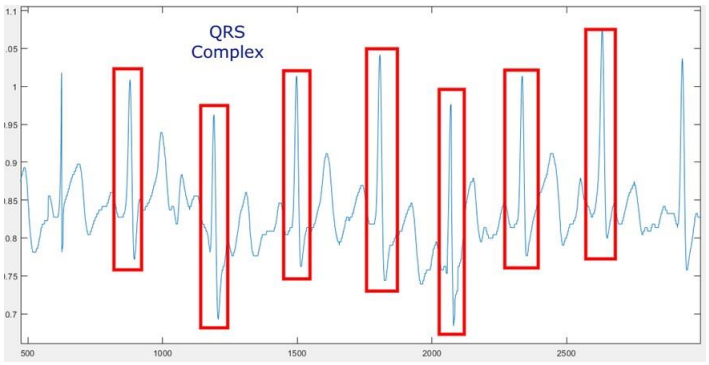

Figure 3: Shape of QRS complex in normal ECG signal

Next, the abnormal ECG signal is observed to find the R-peak and the QRS complex. As shown in Figure 4, both the R-peak and QRS complex are unclear to be detected in each heart cycle. Furthermore, one R-peak is mis-detected and undetected. Thus, the Wavelet decomposition technique is applied to the abnormal ECG signals to analyze the features computationally.

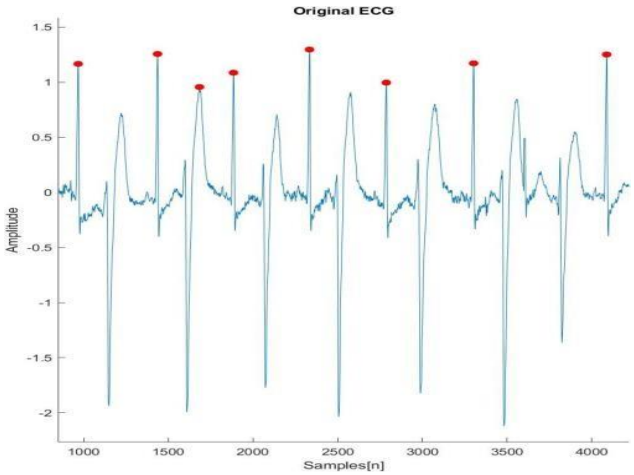

Figure 4: Abnormal ECG signal with unclear R-peak and QRS complex

2.2 Wavelet Decomposition

Wavelet is a type of time-frequency analysis that provides information about both frequency and time within signals. The main advantage of using Wavelet is that it could be varying window size which is broad at low frequencies and narrow at high frequencies thus leading to an optimal time-frequency resolution in all frequency ranges. Here, the Wavelet decomposition is applied to the abnormal ECG signals to perform both down-sampling and noise reduction in a single step. It replaces the band-pass filtering used in a few representative ECG signal analysis methods.

3. Results and Discussion

Figure 5 shows the results of decomposed abnormal ECG signals using different Daubechies values. The undetected and mis-detected R-peaks as shown in Figure 4 are indicated correctly in all abnormal ECG signals. Simultaneously, the decomposed signals have filtered out the noises that might interrupt the appearance of peaks. However, the down-sampling technique has reduced the sample numbers, thus, stretching the signals in becoming less complicated and less shaped in detecting the QRS complex.

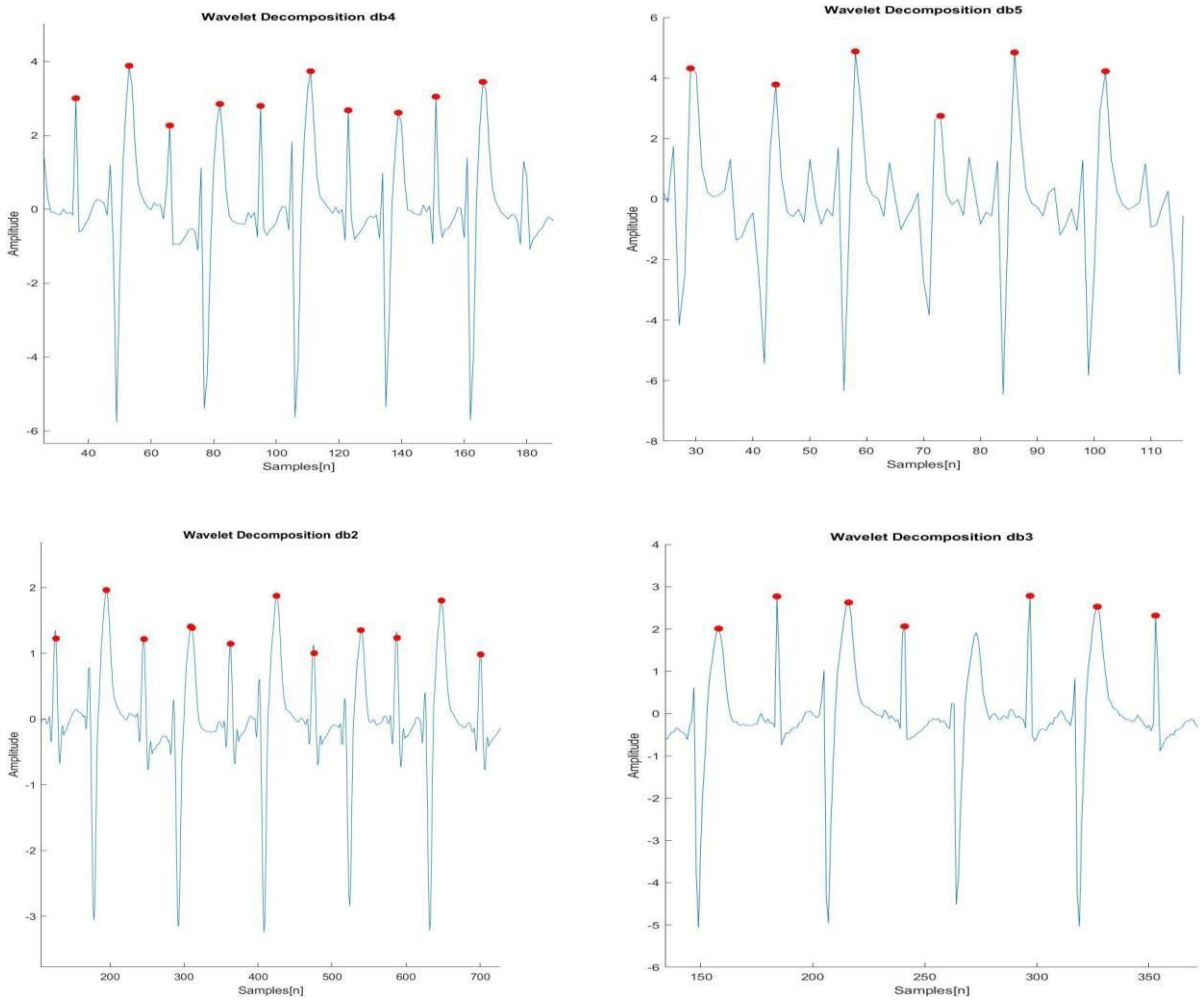

Figure 5: Abnormal decomposed ECG signal indicating the R-peak using (a) Daubechies 2 (db2), (b) Daubechies 3 (db3), (c) Daubechies 4 (db4), and (d) Daubechies 5 (db5)

In general, the normal ECG signal has rhythmically waved that easy to determine and detect the R peak without error. However, the R peak in abnormal ECG signals is sometime mis-detected due to unwanted noises. Thus, the abnormal ECG signal needs to down-sample so that the resolution of the

signal will increase, and it will be easy to detect the R peak. Down-sampling is the process of reducing the sampling rate of a signal. Down-sample reduces the sampling rate of the input by an integer factor by picking up one out of N samples. Note that no anti-aliasing filter is applied to the original data. While doing the process of down-sampling the shape of the data will not change but what will be decreasing is the sampling rate of the signal. As the result, the R peak has successfully detected all the abnormal signals from the database.

4. Conclusion

This work presented the approach using Wavelet decomposition for detecting R peaks of the normal and abnormal ECG signal in the QRS complex. This also demonstrates the possibility of obtaining high-peak detection accuracy in ECG signal analysis. In this paper, we only detect the R peak and further processing procedures can be done for the extraction of the QRS complex that is more informative in the investigation of ECG signals. In addition, the proposed methods in this study have been transacted on just three samples. More real data in various cases are needed for justifying the conclusion and generalization of the results. In the future, it is suggested to analyze and detect different peak points in ECG signals such as T-wave and S-wave. Detecting various types of peaks in ECG signals will provide more useful information for diagnosing and creating several related applications.

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