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The Development of ST-Episode Detection in Holter Monitoring for Myocardial Ischemia

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Abstract

Currently, cardiac arrhythmia is a major cause of life threatening. Electrocardiogram (ECG) is the most useful physiological signal that is used in clinical diagnosis. Some abnormalities of heart functions can be investigated from ECG morphology. Many research works present that the changing of ST-T complex is a crucial parameter related to myocardial ischemia. Therefore, this paper reports our progress in ST-episode detection using time domain analysis. The database used in this study is European ST-T database from Physionet. As the results, the performance of our proposed technique can correctly detect ST-episode with 91.37% of sensitivity.

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Keywords: ST-Episode; Electrocardiogram; Myocardial Ischemia

1. Introduction

Nowadays heart disease is an important issue in several countries. Electrocardiogram (ECG) is a physical signal that is very helpful in the diagnosis of heart disorders. The ECG morphology is very helpful information in clinic. The abnormality of ECG morphology is related to the functional disorder of heart. Several literatures present that the changing of ST-T complex is a crucial parameter related to myocardial ischemia. The transient ST segment and T wave are important components in diagnosis of ischemia. Therefore; modern ECG monitoring has embedded function for detection of transient ST segment and T wave. In 1995, Taddie A. and colleague proposed 2-lead ECG analysis in time series to measure the episode of ST segment vector [1]. Several research groups applied Karhunen–Loe`ve

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transform-based algorithm for detection of transient ST segment episodes [2-4]. In 2006 Milosavljevic N. and colleague proposed wavelet transform-based technique to extract some characteristic features of ECG to detect ST segment [5]. This study proposes technique for measuring the ST deviation with time domain analysis.

2. Methodology

2.1. Data Study

The European ST-T Database available in Physionet was used in this study to develop algorithm in measurement of ST deviation and ST-Episode detection [6]. There are 90 annotated excerpts of ambulatory ECG recordings from 79 subjects. Forty six records from database were used in our study. Each record consists of two ECG traces sampled at 250 Hz with 12-bit resolution. Two cardiologists independently evaluated to annotate changes in ST segment and T-wave morphology. Fig. 1 shows the morphology of ECG signal. The definitions of important annotations are:

- *ST segment deviations* are measured from 80 ms after the J point (if heart rate does not exceed 120 bpm) or 60 ms after the J point otherwise.
- *ST Episodes* can be evaluated if ST deviation is higher than 0.1 mV continuously more than 30 seconds.

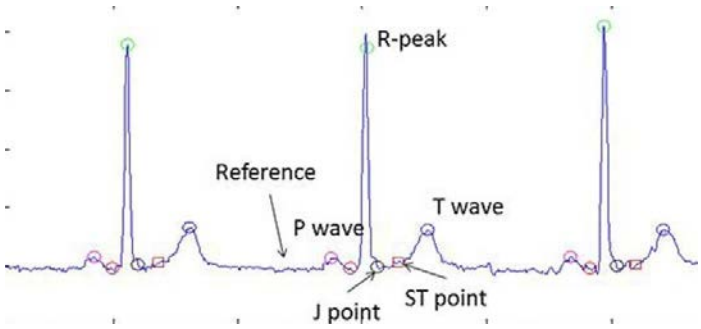

Fig. 1. The morphology of ECG

2.2. The measurement of ST Segment Deviation

The ST segment deviation can be calculated from the absolute value of the difference between values of the ST segment on the reference as presented in Eq. 1

$$ST_{dev} = |ECG_{ST} - ECG_{ref}| \quad (1)$$

where ECG_{ST} is the amplitude of the ST segment after J point. The ST segment is measured 60 ms after the J point if R-R interval is less than 0.5 s and 80 ms after the J point if R-R interval is more than 0.5 s. ECG_{ref} is the reference that is the amplitude of ECG prior to P wave as shown in Fig. 1. The procedure in calculation of ST_{dev} position of J point and P wave are required for calculation of ST_{dev}. The methods to detect J point and P wave are described as follow:

2.2.1. J point and ST point detection

In this stage the ECG was transformed into time-frequency domain using short time Fourier transform (STFT) as shown in Fig 2. The temporal information in selected frequency band (7 to 30 Hz) was considered in J point localization as shown in Fig. 3. It can be noticed that the J point can be detected from the first minima point after R wave. Our technique for R wave detection has been reported in previous work [7]. The location of ST point is then marked depending on heart rate at 80 ms or 60 ms after J point.

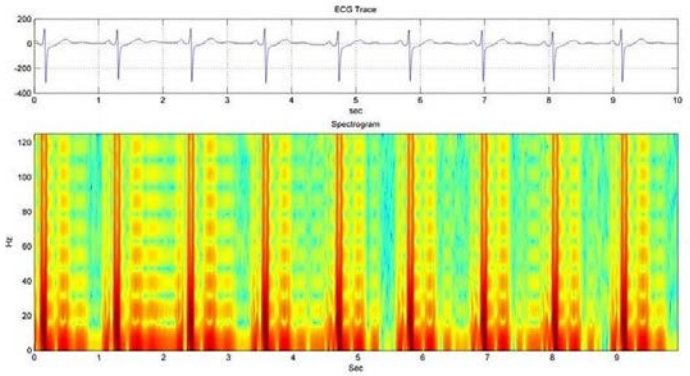

Fig. 2. The spectrogram of ECG

2.2.2. P wave localization and measurement of ECG_{ref}

P wave of each beat is determined from cropped signal which is 20% of RR interval prior to R wave. The position of P wave is at the peak location of cropped signal. The ECG_{ref} is then computed from average amplitude of ECG segment before P wave.

2.2.3. Measurement of ST deviation and ST Episode detection

ST deviation (ST_{dev}) can be calculated from the difference of ECG at ST point compared to reference as shown in equation 1. Then ST_{dev} function is then smoothed with window averaging technique. From the definition in *Physionet*, the ST-episode is determined when the ST_{dev} is higher than 0.1 mV continuously for more than 30 seconds.

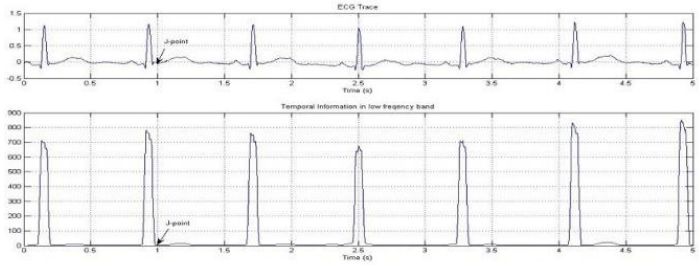

Fig. 3. The position of detected J-point

3. Results and Discussion

Fig. 4 shows the STdev function of ECG file number ‘e0129’ for two-hour length. Referred to annotation in database, this file contains five ST-episodes as shown in Figure 4. All ST-episodes can be detected using our proposed method in this experiment. The proposed algorithm was also tested with 46 records from the European ST-T database which contains 139 ST-episode events. The overall results are presented in Table 1. This algorithm can detect 279 ST-Episode from 46 studied records which are 127 episodes of true positive and 152 episodes of false positive. In addition to there are 12 episodes of false negative in detection. The performance of ST-episode detection can be

evaluated for 91.37% of sensitivity and 45.52% of precision. The sensitivity of this proposed algorithm is quite high whereas there are some errors for false positive causing poor precision index.

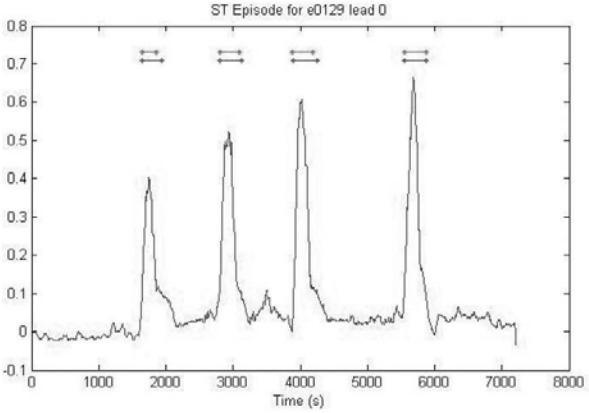

Fig. 4. Testing Result with file number *'e0129'*

Table 1. The experimental results

Reference ST-Episode	Detected ST-Episode	True Positive	False Negative	False Positive
139	279	127	12	152

4. Conclusion

This paper reports our extended work in development of ST Episode detection. The proposed method was tested with the European ST-T database. The performance of our proposed method can detect the ST-episode with the sensitivity of 91.37%. However, the false positive result is still poor because some errors were found in case of arrhythmias such as VT signal. Future work will develop the preliminary research work outlined here. Other time-frequency based method such as wavelet transform should be applied to improve the performance of detection.

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