Ventricular Premature Beat Detection in ECG using Correlation Techniques

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Abstract

Correlation techniques are used to find whether the electrocardiogram (ECG) is normal or abnormal. These correlation techniques could be further used to detect the type of abnormality present in the abnormal ECG. Reference ECG signals could be stored for all type of abnormalities and the test ECG signal if correlated with the stored references will give highest correlation percentage with the type of abnormality present in it. Arrhythmias are one of the abnormalities in ECG. Among various arrhythmias one of the life threatening arrhythmia is Ventricular premature beat.which occurs when an ectopic pacemaker fires early, before the sino atrial impulse has a chance to reach it. In this paper, to demonstrate the proposed technique of detecting the type of abnormality present in ECG, two types of reference ECG signals are stored; Ventricular Premature Beat and normal ECG Beat. Every test ECG beat is correlated with the two beats. The test beat is declared to be the type of the reference beat with which it has maximum correlation.

Keyword: Correlation; Electrocardiogram; Abnormality , Ventricular Premature Beat

1. Introduction

Cardiac problems are threatening the whole world day by day. Electrocardiography, i.e. ECG is one of the most common tests to diagnose the heart problems. Detection and treatment of arrhythmias is one of the cardiac care unit's major functions. Few of the arrhythmias are Ventricular Premature Beats, Asystole, Couplet, Bigeminy, and Fusion Beats. In Ventricular Premature Beats (VPB), there is premature ventricular contraction arising in diastolic period of the preceding sinus beat followed by compensatory pause. Couplet is the case where pair of VPBs is observed. In Asystole, there is a lack of conduction observed for an extended duration. Bigeminy is the presence of VPB between alternate normal beat. Fusion beat is a parasystolic condition in which two pacemakers in heart discharge at their own inherent rate, occasionally causing simultaneous invasion of ventricular musculature, each activating part of ventricles. The resulting QRS complex has a configuration intermediate below 'pure' sinus beat and pure ventricular beat [1].

Millions of ECG are taken worldwide each year for the patients with different cases. The ECG are analysed by the experienced doctors who depending upon their knowledge predict out the problem(s) associated with the patient. If the morphological disturbance in ECG becomes somewhat complex as in the case of Ventricular Premature Beats and Fusion Beats, then the analysis by different doctors vary depending upon their experience. This experience based analysis gives different interpretations. Hence there is a need of a system that could analyse the ECG signals properly and with a great accuracy so that there is a less chance of mistake as well as the problem is spotted in time so that an early treatment could be started. To achieve this objective many works have been done in this field which has given promising results to such complex problems [1]-[7].

Many works have been done in this area and Artificial Neural Networks give highest accuracy but the drawback of this method is that it requires a huge database to train the networks. Hence in this paper a method is proposed which uses correlation techniques using MATLAB tools.

2. Methodology

For analysis the standard Massachusetts Institute of Technology-Beth Israel Hospital (MIT-BIH) database is used. MIT-BIH Database is the standard ECG database which is used universally for ECG analysis purpose. The ECG from Arrhythmia database having Ventricular Premature Beat and Normal ECG Beat are stored as references shown in fig. 1. ECG beat is taken as a signal. The ECG beat taken here consists of 150 samples, i.e. 49 at left from R peak and 100 samples at right from R peak. This is done to cover the features in ECG beat properly and optimised value is chosen to save the memory space and time of result detection.

Every test signal is cross-correlated with these two stored reference signals and the abnormality of the ECG beat is judged on the correlation percentage obtained [8-12].

Cross-correlation

Cross-correlation is used to find out similarity or relationship between the signals $x(n)$ and $y(n)$ delayed by arbitrary delayed factor K. $y(n-\mathrm{K})$ is the signal delayed by factor K. n is the number of samples in the sequence [8]. Cross-correlation function for discrete time signals $x(n)$ and $y(n-\mathrm{K})$ is given by equation 1.

$$R_{xx}(\mathrm{K}) = \frac{1}{N}\sum_{n=0}^{N-1} x(n)y(n-\mathrm{K})$$

If $R_{xx}(0)$ is the cross-correlation function of input x and x at zero time lag, $R_{xy}(\mathrm{K})$ is the cross-correlation function of input x and y at K[th] time lag, then the normalized cross-correlation function, $\rho_{xy}(\mathrm{K})$ is given by equation 2 [8].

$$\rho_{xy}(\mathrm{K}) = \frac{R_{xy}(\mathrm{K})}{\sqrt{\left(R_{xx}(0)\right)\times\left(R_{yy}(0)\right)}}$$

Range of normalized cross-correlation function is:

$$|0 \leq |\rho_{xy}(\mathrm{K})| \leq 1|$$

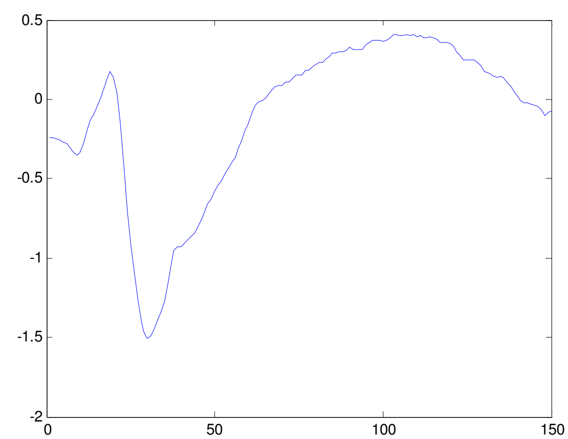

Fig. 1 : Reference Ventricular Premature Beat

Correlation Coefficient

The following mathematical formula is used to compute the correlation coefficient between *X* and *Y*, where, *X* and *Y* are matrices or vectors of the same size [8].

$$r = \frac{\sum_m \sum_n \left(X_{mn} - \bar{X}\right)\left(Y_{mn} - \bar{Y}\right)}{\sqrt{\left(\sum_m \sum_n \left(X_{mn} - \bar{X}\right)^2\right)\left(\sum_m \sum_n \left(Y_{mn} - \bar{Y}\right)^2\right)}} \quad (1) \quad (4)$$

Where, $\overline{X} = mean\ of\ X$ and $\overline{Y} = mean\ of\ Y$

Correlation Percentage

To find out the similarity of one variable to other variable in percentage, the square of correlation coefficient i.e. r^2 is calculated which is known as coefficient of determination. Correlation percentage is the percentage of coefficient of determination [8].

$$\text{Correlation}(\%) = r^2 \times 100 \quad (5)$$

3. Experiments and Results

Some ECG beats from MIT-BIH Arrhythmia database were correlated with the stored reference beats. Ventricular Premature Beat Record 1 (VPB2.R1) is correlated with both the reference beats and the correlation curves obtained is shown in fig. 2. Similarly, Normal Beat Record 1 (N.R1) is correlated with both the reference beats and the correlation curves obtained is shown in fig. 3.

Correlation Percentage of VPB2.R1 with VPB2.RR = 96.4966 %

Correlation Percentage of VPB2.R1 with N.RR = 20.3124 %

Correlation Percentage of N.R1 with VPB2.RR = 19.2736 %

Correlation percentage of VPB2.R1 with VPB2.RR obtained is higher than obtained with N.RR because it is Ventricle Premature Beat and correlation percentage of N.R1 with VPB2.RR obtained is lower than obtained with VPB2.RR because these are different beats.

The other records were similarly correlated with both the reference beats and the type of abnormality was decided on the basis of correlation percentage obtained. Test beat is declared to have the type of abnormality with which it gives more correlation percentage. Table 1 shows the correlation percentage obtained with both the reference beats.

Table 1 Correlation Percentage of different records with both reference beats

Abnormal Record	**Correlation (%) with VPB2.RR**	**Correlation (%) with N.RR**
VPB2.R1	96.4966	25.0319
VPB2.R2	95.3771	29.4806
VPB2.R3	85.1587	21.1254
VPB2.R4	88.4545	19.5678
VPB2.R5	82.2970	22.6743
VPB2.R6	88.0230	34.9021
N.R1	38.9207	98.5566
N.R2	32.7908	97.2357
N.R3	36.9267	98.3487
N.R4	48.1227	98.3012
N.R5	30.1455	97.2612

4. Conclusion

Correlation analysis is the simplest method to find out the type of abnormality present in ECG and also it is easy to implement unlike other studies, result are showing 100% accuracy, as all the normal beats with normal reference give correlation above 90% and all the Ventricular premature beats give correlation with Ventricular premature beat reference above 80% .The study is thus useful to analyse the ECG signals properly and with a great accuracy so that there is a less chance of mistake as well as the problem is spotted in time.

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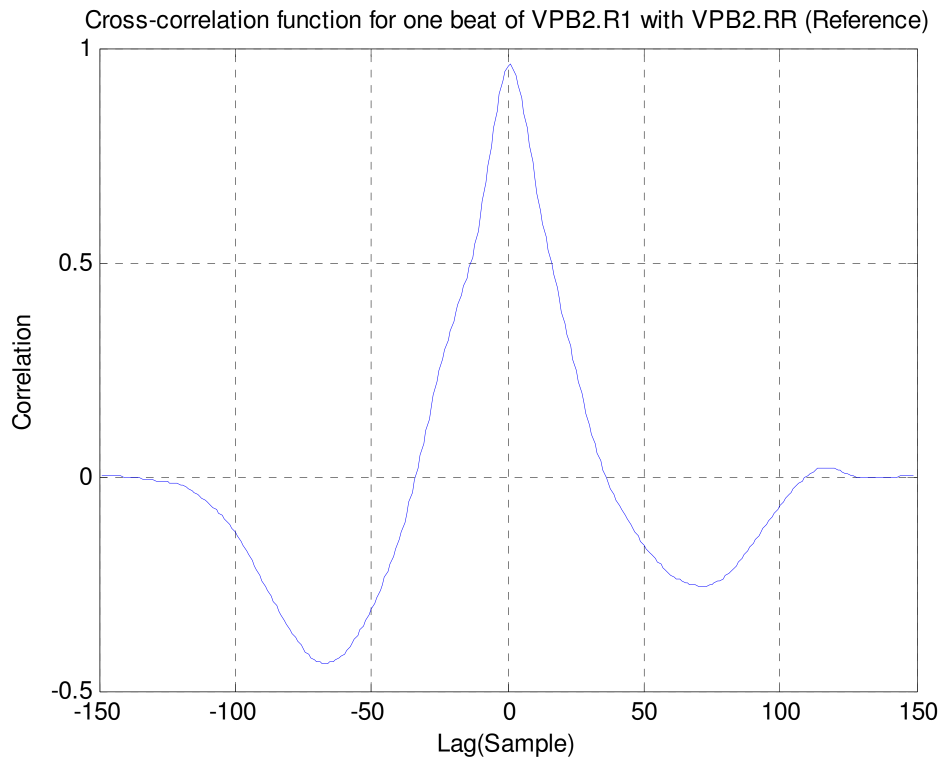

Fig. 2(a) Correlation of VPB2.R1 with VPB2.RR

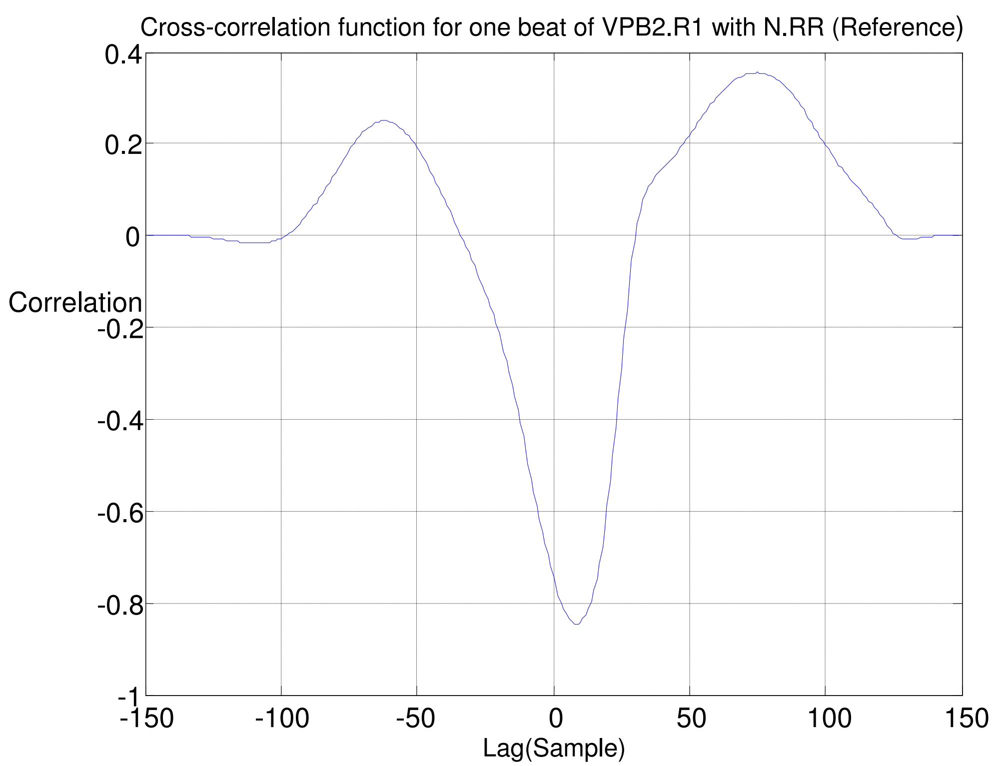

Fig. 1(b) Correlation of VPB2.R1 with N.RR

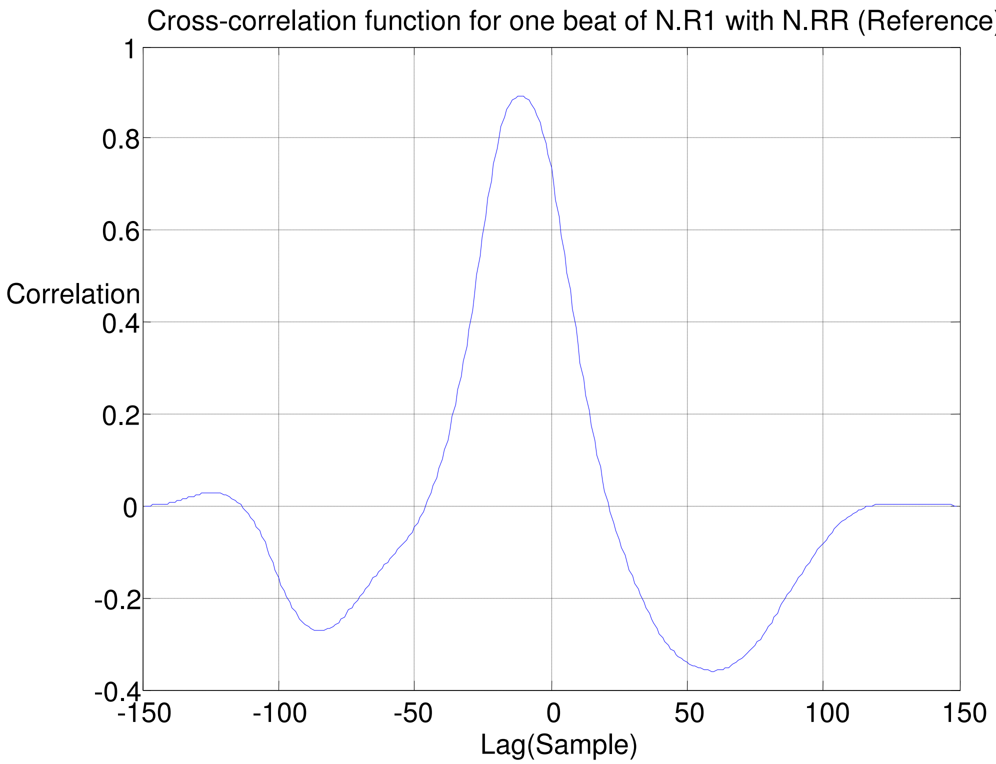

Fig. 3(a) Correlation of N.R1 with N.RR

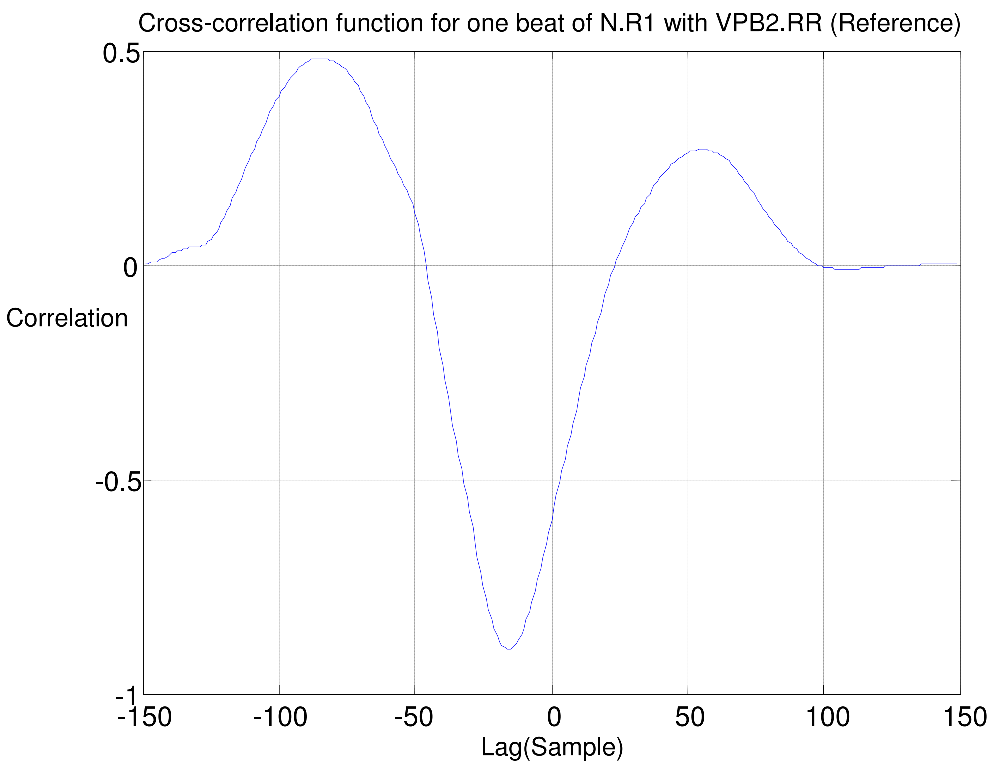

Fig. 2(b) Correlation of N.R1 with VPB2.RR