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The detection method to determine localization and extent of myocardial infarction: A literature review

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ABSTRACT

Cardiovascular diseases is very important to detect as early as possible because it leads to death in the world, and Myocardial Infarction (MI) is very dangerous one among those diseases. Patient monitoring for an early detection of MI is most important to alert medical assistance and increase the vital prognostic of patients. In this paper, trying to detect the Myocardial Infarction, where it is exactly and upto which extent. PhysioNet challenge 2007 Database the Body surface potential map database which consists of ECG of normal and myocardial infarcted patients is used. Since the data available is less, Bilinear Interpolation is used to generate data from the existing. PhysioNet challenge 2007 database has BSPM data. Data is all about four patients with MI, where two patient's data are used as training set to determine rules, and two other patients for testing set. The Myocardial Infarction is detected using some rule and threshold values using Artificial Neural Network. The accuracy might be increases when one patient data follows multiple rule and compared by other patients data.

Keywords: *Myocardial infarction (MI), Body surface potential map (BSPM), Left ventricle (LV), Right ventricle (RL).*

1. INTRODUCTION

Cardiovascular diseases are the leading causes of death worldwide, and MI is commonly known as heart attack, which seems most serious one. A heart attack occurs when the flow of oxygen-rich blood to the section of heart muscle suddenly becomes blocked and the heart can't get oxygen. Coronary Heart Disease (CHD) is the result of heart attack. CHD is a condition in which a waxy substance called plaque builds up inside of the coronary arteries. Right and left side of the heart is the two main blood supplies to pump the heart. More work is secured in the left ventricular because heart is in the left side. Only some portion is bending towards right. ECG signals has 12 leads which executed the result of left ventricle only, while BSPM signals has 352 leads which capture the motion of left as well as right ventricle. Left ventricle can't be ignored because some portion of heart is in the right side as well. Only 50% patients with MI were diagnosed by ECG in the early stage of MI. [1] the four actual advantages of using BSPMs are condensed by comparing BSPMs to other ECG acquisition methods.

BSPM is more sensitive to regional cardiac events. Widespread, direct torso sampling. Emphasis on spatial features of cardiac field and Permits evaluation of cardiac equivalent generator models. Permits evaluation of cardiac equivalent generator models. An ECG measures electrical activity of the heart through electrodes, and the activity of heart are translated into a printed or onscreen readout. The electrical activity image looks like a line graph with the peaks and valleys. An ECG signal shows three waveforms. The "P" wave indicates electrical impulse in the upper chambers of the heart. The "QRS" wave records the electrical activity into the lower chambers. The "T" wave reflects the heart's return to rest. The shape and size of the waves, the time between each wave, and the rate and regularity of beating provides valuable information for the diagnosis of heart disease. In addition to providing insight into the heart's rhythm, the ECG helps doctors determine the size of the heart chambers, detect heart muscle damage.

Definition: Myocardial Infarction (MI) is the irreversible death of heart muscle secondary to prolonged lack of oxygen (Ischemia), Diminishing supply of oxygen (Injury) or Cardiac cells die of anoxia (Infarct).

2. EXISTING METHODS TO DETECT MYOCARDIAL INFARCTION

Several approaches to detect myocardial infarction are known from literature, such as Determine Localization and Extent of Myocardial Infarction using Body Surface Potential Map Data[1], Neural Network Classification [2],Rule based method [3], Innovative approch of Torso Plane [4], Optimization of Electrode Positions of a Wearable ECG Monitoring System [5], Feature Selection in Body Surface Potential Mapping [6], Hybrid System with Hidden Markov Models and Gaussian Mixture Models [7], A Comparison of Various Decision Systems and Learning Algorithms [8], Estimating Infarct Severity from the ECG using a Realistic Heart Model [9], ECG Codebook Model[10].

2.1 Determine Localization and Extent of Myocardial Infarction using Body Surface Potential Map Data

A method for determining the location and extent of myocardial infarction using BSPM data that was obtained from PhysioNet challenge 2007 database has been suggested. This data is related to the four patients with MI that we used from two patients as training set to determine rules, and from two other patients for testing set and the conclusion of the proposed model. At first, T-wave amplitude, R-wave amplitude and integration of T-wave as three features of ECG signals were extracted. Then with definition and applying several rules and threshold levels for those features, areas that are with MI and these extents were diagnosed. In this study to determine the precise location of MI, 17-segments standard model of left ventricle (LV) was used. The main advantages of this method were its simplicity and high accuracy.

2.2 Neural Network Classification

Data used here contain BSPM signal of four patients and their actual infarcted segments (two training cases and two cases for test). By mapping Q-wave integral and QRS-complex integral on torso surface and applying four threshold-based rules, an abnormal area on the torso can be obtain. This detected abnormal area then is mapped to the heart segments. A NN classifier is used at final step. The results expressed by parameter OS (overlapped segment) which is a value between 0 and 1, where 1 is a perfect match. However further works is needed to improve the results.

2.3 Rule-based Method

A method for determining the location and extent of myocardial infarction using Body Surface Potential Map data of PhysioNet challenge 2007 database is presented. This data is related to four patients with myocardial infarction. We used two patients as training set to determine rules and two other patients as testing set of the proposed model. First, T-wave amplitude, T-wave integral, Q-wave amplitude and R-wave amplitude as four features of ECG signals were extracted. Then we defined several rules and proper thresholds for localization and determining the extent of myocardial infarction. To determine the precise location and extent of myocardial infarction, 17-segment standard model of left ventricle was used two main advantages of this method are simplicity and high accuracy.

2.4 Innovative Approach of Torso Plane

Method: Here, address a method base on behavior of some ECG's features, which are Q, amplitudes and ST dispersion. We call these Q and ST curves. At the first step, by plotting the variability of Q, amplitude and ST dispersion for nodes which lies in lines on torso plane, these curves are obtained. The behavior of the mentioned curves for normal lines both in horizontal and vertical line differ from the abnormal ones. A threshold method is used here to determine the infarcted area.

2.5 Optimization of Electrode Positions of a Wearable ECG Monitoring System

Electrocardiogram provides a non-invasive and inexpensive way for diagnosis of myocardial infarction through seeking for the ischemic syndromes in ECG, e.g., the elevation or depression of ST-segment. However, the standard 12 lead ECG does not examine the heart from all aspects. On the other hand, the comprehensive body surface potential mapping system is nearly impossible to be wearable. In the present project a wearable ECG monitoring system for detection of acute myocardial infarction is optimized with respect to electrode positions.

2.6 Feature Selection in Body Surface Potential Mapping

Body surface potential mapping is an extension of the conventional electrocardiography. Body surface potential mapping, measured from multiple places on the thorax, is a graphical representation of cardiac activity that enables us to acquire more data for more complex analysis of heart cycle. In this paper new features are presented and the methodology of obtaining them is described.

Data Acquisition

Cardiag 112.2 system (Czech-made BSPM device) with 80 electrodes in 16 x 5 equidistant matrix was used for measurement - see Figure 1. The system allows recording of standard ECG, vector-cardiograph and BSPM.

Data Preprocessing

After all 95 signals consisting of 12 standard ECG leads, 3 orthogonal leads (VCG) and 80 mapping leads, signals are filtered with 50Hz notch filter to remove power-line frequency, and with set of adaptive filters for removing of breathing and MEG artifacts.

Signal Analysis

Further step in the preprocessing phase was signal analysis – example of the program window of signal analysis see on Figure 2. We used wavelet-based signal detector that uses signal decomposition that uses discrete wavelet transformation to detect P, Q, R, S and T-waves onsets and offsets.

2.7 A Hybrid System with Hidden Markov Models and Gaussian Mixture Models

This presented a new diagnosis system with integrating 12-lead ECG data into a density model for increasing accuracy rate and flexibility of diseases detection. A hybrid system with HMMs and GMMs was employed for data classification. For myocardial infarction, data of lead-V1, V2, V3 and V4 were selected and HMMs were used not only to find the ECG segmentations but also to calculate the log likelihood value which was treated as statistical feature data of each heartbeat's ECG complex. The 4- dimension feature vector was clustered by GMMs and different numbers of distribution (disease and normal data) were examined in experiment. The main idea in this study relied on the multiple ECG channels which could be combined. There were total 1129 samples of heartbeats from clinical data, including 582 data with myocardial infarction and 547 normal data.

2.8 A Comparison of Various Decision

Systems and Learning Algorithms Here compared the best known scoring/coding/decision systems (the Selvester QRS score, the Novacode, and the Siemens 440/740) and several learning algorithms (Ripper, C4.5, and SVM). The decision systems were developed with different purposes (the Selvester for estimation of MI size, the Novacode for clinical and epidemiologic studies, and the Siemens for ECG device Siemens 440/740). In this work we combined these systems with additional simple rules and compared performance to: (i) decision systems alone, (ii) base classifiers (Ripper, C4.5, and SVM). Our database consisted of 2596 ECG records annotated by experienced cardiologist. Among decision systems the Selvester and the Siemens had F-measure 54% and 51%, respectively. Meaning that about 50% of MI's were correctly classified. Even lower Fmeasure of 39% was obtained by Novacode. Better results were achieved using rule miner Ripper with F-measure of 68%, however, due to a number of rules created, the resulting model was hard to interpret.

2.9 Estimating Infarct Severity from the ECG using a Realistic Heart Model

The early phase of myocardial infarction is accompanied by changes in the ST segment of the ECG. This makes the ST segment the clinical marker for the detection of acute myocardial infarction. The determination of the infarct severity, location and size of the myocardial tissue at risk will support clinical decision making. In this study we used an inverse procedure to estimate the location and size of the infarcted heart region. The method estimates the local trans membrane amplitude based on the ECG amplitude near the J-point of the standard 12 leads signals using a patient specific volume conductor model. For the 5 available patient cases the positions as well as the size of the estimated infarct region were in accordance with results based on MRI.

2.10 ECG Codebook Model

ECG is a kind of high dimensional dataset and the useful information of illness only exists in few heartbeats. To achieve a good classification performance, most existing approaches used features proposed by human experts, and there is no approach for automatic useful feature extraction. To solve that problem, we propose an ECG Codebook Model (ECGCM) which automatically builds a small number of codes to represent the high dimension ECG data. ECGCM not only greatly reduces the dimension of ECG, but also contains more meaningful semantic information for Myocardial Infarction detection

3. COMPARISON OF DIFFERENT METHODS

The overall accuracy of first method i.e. Determine Localization and Extent of Myocardial Infarction using Body Surface Potential Map Data that expressed with SO parameter and EPD parameter for two patients in test set was obtained to 0.94 and 5.37, respectively. The results of Neural Network Classification for two test cases are OScase#3=0.7 and OScase#4=0.4 shows this mathematically simple method can predict the location of MI reasonably. Overall accuracy of Rule based Method with SO, CED and EPD parameters. We obtained 1.16, 1 and 5.3952 for SO, CED and EPD, respectively, in our test data.The Innovative ApprochesofTorso Plane is evaluated on Challenge 2007 database. The results are EPD=8, SO=0.944, and CED=1. The method achieved the best EPD and CED scores and the second place for SO and overall ranked the highest scores (first rank) in CinC/PhysioNet Challenge 2007. The optimal electrode configuration suggested in the study of Optimization of Electrode Positions of a Wearable ECG Monitoring System includes 2 pairs of electrodes and a high sensitivity of 98% is achieved in the sense of "no infarction is missed" in the validation. In Feature Selection in Body Surface Potential Mapping Usability of the features is demonstrated on dataset consisting of pregnant, non-pregnant and after-delivery women. The sensitivity of this diagnosis system achieved 79% and predictivity achieved 68.70% statisticall of Hybrid System with Hidden Markov Models and Gaussian Mixture Models. In Comparison of Various Decision Systems and Learning Algorithms combination of decision systems with additional simple rules create by AdaBoost yielded the best performance with F-measure 71%, sensitivity (Se) 78%, and specificity (Sp) 95%. In Estimating Infarct Severity from the ECG using a Realistic Heart Model the 5 available patient cases the positions as well as the size of the estimated infarct region were in accordance with results based on MRI. ECG Codebook Model experiment results show that ECGCM achieves 2% and 20.5% improvement in sensitivity and specificity respectively in Myocardial Infarction detection.

4. CONCLUSION

In case of Determine Localization and Extent of Myocardial Infarction using Body Surface Potential Map Data is useful to detect and MI position based on 352 leads implemented over four patients were presented method PhysioNet challenge 2007 database related to four patients with MI, where two patients used as a training set and remaining two patients used as a testing set. BSPM has 352 leads to detect the location and extent of MI. Where adding further patient's data by using method like Bilinear Interpolation to test existing data and with the help of ANN Artificial Neural Network possible to train the Network to know the results is good to implement.

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