Reviewing Different ECG-Signal Feature Extraction and Classification Approaches

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Abstract: Electrocardiogram (ECG) is continuous recording of electrical signals of heart against time. The analysis of ECG signal is essential and proves important in detecting cardiac peculiarities. Electrocardiographic signals are nothing but numerous presence of noise added from different sources. Some commn noise source that affect or disturb basic electrocardiogram are mainly power line interference, medical operating devices noise and electromagnetic field interference from other sources, noise due to random body movements and breathing movements. Noises are classified on basis of their frequency content and time variation. It is absolutely necessary to reduce these disturbances in ECG signal to improve accuracy and reliability. Noise minimizes after removing high and low frequencies. Basic classification is performed in two class namely abnormal and normal signal. ECG signal gets classified on intervals in PR, RR and QRS width from this decision rules are form. At primary stage abnormal signal of human heart detect cardiac patients. This paper reviews and summarizes about the ECG signal classification.

Keywords: ECG, P-QRS-T segment, RR, PR, Noise, Classifiers, Discrete wavelet transform,

1 INTRODUCTION

A Project under the leadership of late J. I. Williams started by European community in the year 1980, with an aim of establishing "Common Standards for Quantitative Electrocardiography"(CSE). The working party developed for CSE reference databases. In a decade extensive level of the research has been occurred mainly on the transforming of biomedical signals. Daily clinical practice generates any measure of biomedical signals from checking of patients and for suggestive purposes. Accordingly automatic processing frameworks are often utilized as a part of medical data investigation. New techniques can streamline and accelerate the handling of huge volumes of information. The doctor regularly needs to choose a particular patient's diagnosis on the premise of various numerical qualities measured from examination. Introduction in this volume of information is not generally simple and unambiguous. Subsequently there exist consultation frameworks that are helpful and with minimize human errors. Electrocardiogram (ECG) is nothing but record of electrical energy signals that are produced by the organ named heart. The electrical wave gets generated from depolarization and repolarisation of some cells due to movement of Na+ and k+ ions present in the blood [5]. The ECG signal generally in range of 2 mV and requires recording bandwidth of 0.1 to 120 Hz [1]. The ECG generated is acquired by an introduction of instruments into the body, i.e. nothing but placing electrodes at standardized locations on the skin of the patient [2]. The ECG signal along with heart rate revolves the cardiac health of human heart organ. Any abnormal change in heart rate or rhythm or changes in morphological pattern of ECG signal are indicatice of cardiac arrhythmia. Changes are detected and diagnosed by analyzing the recorded ECG waveform. The amplitude and duration of the P-QRS-T-U wave contains useful information about the nature of disease related to human heart organ.

2 ELECTROCARDIOGRAM (ECG)

Electrocardiogram or ECG is an electrical signals recording of the human heart and is used in the examining of various heart disease.

The MIT/BIH arrhythmia database is used in the study for performance evaluation. This ECG can be classified into two first as normal and second as abnormal signals. One of the most important problems rather issues in ECG analysis is automatic beat delineation [4].

This is needed in many cases ranging from simple heart rate computations to serving as the first stage of complex automatic diagnosis. Beat delineation techniques had to start by identifying features in the ECG signal that can be constantly detected in each heartbeat. Simply by looking at an ECG plot, shown in figure 1 it can be noticed that the QRS complex is the

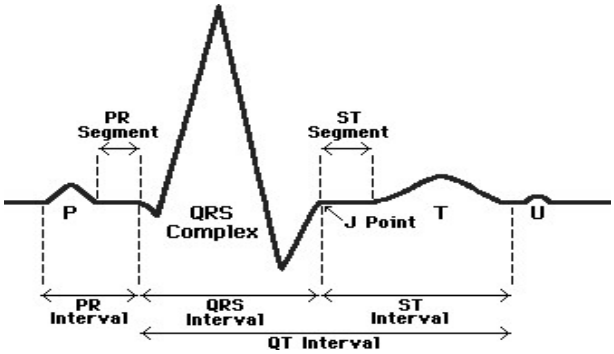

Fig -1: ECG Signal Interval

predominant feature in every beat. The other features of the ECG signal, like the P wave and T wave, are sometimes too small to be

detected [3]. This makes the QRS complex the feature that can yield the best detection accuracy. Table 1 shows different features of ECG along with the intervals and amplitudes.

TABLE -1: DIFFERENT FEATURES OF ECG ALONG WITH THE INTERVALS AND AMPLITUDES.

Features/Interval	Amplitude	Duration
P wave	0.1- 0.2mv	80 ms
PR	_	120-200 ms
QRS complex	1 - 1.2 mv	80-120 ms
J point	_	_
ST	80-120 ms	ST interval
T wave	0.12-0.3mv	160 ms
QT	_	290-429ms
U wave	_	_
RR	_	0.2-1.2 s

ECG is a bioelectric signal, which records electrical activity of heart against time. That makes, it is an important diagnostic tool for assessing functioning of human heart [4]. ECG is captured by placing electrodes on the skin of the patient. This signal provides the following information about human heart [5].

- Heart rhythm and conduction disturbances
- Abnormalities in the spread of electrical impulse across the heart.
- Indicative information about a prior heart disease like heart attack.
- Symptoms about coronary artery disease.
- Abnormal thickening or hardening of heart muscle.
- Indication about supply of less oxygen to the heart.
- Myocardial ischemia location and extent.
- Electrolyte concentrations changes.

3 LITERATURE REVIEW

The European community in the year 1980, with an aim of establishing "Common Standards for Quantitative Electrocardiography (CSE)".the working party developed for CSE reference databases. In a decade extensive level of the research has been occurs mainly on the transforming of biomedical signals. Daily clinical practice generates any measure of biomedical signals from checking of patients and for suggestive purposes in [1, 2]. The ECG generated is acquired by an introduction of instruments into the body, i.e. nothing but placing electrodes at standardized locations on the skin of the patient [2, 3].

Abnormalities in ECG signal are detected in different stage from pre-processing to classification. Authors [4, 6] implemented pre-processing and classification on MATLAB platform. They classify different arrhythmia classes in normal beats, tachycardia, bradycardia and myocardial infract. In this noise reduction is perform in pre-processing using Biorthogonal wavelet and for classification basic morphological classification technique is used.

In Automatic classifier of the Electrocardiogram (ECG) LDA and NN were consider for classifier model and also used for detection of normal, premature ventricular contraction and fusion beat types [13, 25]. Features of the ECG waveform like shape and heart beat intervals were used as inputs to the classifiers. ECG waveform data was collected from the MIT-BIH arrhythmia database. A classification accuracy achieved about to 89% was measure by cross validation. Low glucose is responsible for sudden death of Young people and they found continuous long ventricular repolarisation and it affect the T wave morphology is studied in [19, 25]. ECG signal gets classified into normal and arrhythmic from the Electrocardiogram (ECG) by extracting it's both time interval and morphological features by using ANN and LDA techniques implements as in described in [22,24].

Slope Vector Waveform (SVW) algorithm utilized for ECG QRS complex detection and RR interval evaluation as in [5]. This algorithm works in two stages, firstly variable stage differentiations and then non-linear amplification. Variable stage differentiation is used to extract the features and non-linear amplification used to improve signal to noise ratio. Slope Vector Waveform (SVW) algorithm detects excellent QRS, complex of ECG waveform but it contains impurities like noise as in [5]. ECG signal is de-noised and better (99.18%) sensititivity QRS complex detection is achieved using wavelet filter with scaling function by removing wavelet coefficient at higher scales. This is implemented by Multiresolution Wavelet Transform on MIT-BIH database as in [6, 7].

K-nearest neighbour algorithm [8, 9] is used for extracting the features that are extracted from the electrocardiograph (ECG) signals for the arrhythmia classification. The related results are calculated from consecutive sample values of each R peak in ECG signals and used as features. In addition to these features, different features obtained from the relations of these results are also used. Obtained features ate more discriminative [20]. P and T wave detection is an important part in the analysis and interpretation of ECG. The Non-QRS Features extractions algorithm detects and delineates both P and T - wave simultaneously. It applies a modified definition of slope, of ECG signal, as the feature for detection of ECG wave components. Five feature-components are combined to derive the final feature signal. Amplitude threshold of the final feature signal is employed for distinguishing P and T waves with respect to already detected QRS-complexes. P-wave detection rate of 96.95% with false positive and false negative percentage of 2.62% and 3.01% has been reported. Similarly, T-wave detection rate of 98.01% with false positive and false negative percentage of 3.08% and 1.93% has been reported in [19]. K-nearest neighbour and ANN techniques is utilised for improving classification result obtained from original pattern and re-constructed one in [18,21].It perform for obtained a alignment of the ECG with respect to R beat as it is initial position as a feature

ECG Feature extraction various techniques and algorithm is utilised to diagnosing of cardiac diseases. These feature extractions determine amplitude and interval values of P-QRS-T segment determines the functioning of heart of human.Numerious research is done on ECG by using ANN fuzzy logics methods, etc proposed in [15, 17-19].Neural network classifier is used to classify six type of electrocardiogram signal beats with normal signals

and with proper training set .Features were extracted by Continuous wavelets transform, it increases sensitivity and accuracy to 99.00% achieved in [16]. ANN,HMM,Self organising map and other technique with each one methodology shows its own particular circumstance and burdens because analysing ECG, is conations thousands of heart beats so need to automate classification of heart beats and diagnose heart function correctly proposed in[15,16,18].

Discrete wavelet transform is utilised for reduction of dimensions on non-stationary ECG signals. The data will be analyzed and classified using neuro-fuzzy, ANN [12, 13]. Linear Discriminants analysis distinguishes ECG signal from each other and displays normal, fear, smoking or exercise ECG. But very few errors are involved in it and accuracy is stable in between 90% to 95% as in [13].

ECG Electrocardiogram (ECG) is the P, QRS, T wave indicating the electrical activity of the heart and it is the most easily readable bioelectric signal that provides the doctors with expected accurate data regarding the patient heart condition. Many of the cardiac problems are visible as distortions in the Electrocardiogram (ECG). Abnormal heart beats can occur randomly it becomes very wearisome and time-consuming to analyze 24 hour ECG signal, as it may contain thousands of heart beats. Premature Ventricular Contraction (PVC) and Fusion signals of the MIT-BIH Database used to develop computer based automated system to help the doctor to detect cardiac arrhythmia. Then the various schemes for extracting the useful features of the ECG signals are focused for use with artificial neural networks. The principal characteristics of the signal are extracted using the Principal Component Analysis (PCA) technique and other techniques such as DCT and DWT. After signal pre-processing, they are applied to an Artificial Neural Network Multilayer Perceptron (ANN MLP). The task of an ANN based system is to correctly identify the three classes the feature extraction schemes are discussed and compared with RBFN & Support Vector Machine in [11].

Electrocardiogram (ECG) is used to diagnosing cardio vascular diseases. Automatic beat segmentation and classification of ECG signal is very important since examining each and every beat is a tedious job for most experienced cardiologist also. One after one support vector machine is accurately classified and differentiated Normal and abnormal heartbeats s as like left bundle branch block (LBBB), right bundle branch block (RBBB), atrial premature contractions (APC) and premature ventricular contractions (PVC), atrial premature beat (APB), Paced beats and Fusion beats with efficient range of accuracy. ECG signal are denoised and extract 25 features. The db4 wavelet used for decomposition. ECG signals are obtained from the open source MIT-BIH cardiac arrythmia database. Experiment give the classification accuracy is well above 97 % for all the classes in [10]. ECG signals are collected from MIT-BIH database. The heart rate is utilized as base signal from which some parameters are studied and displayed to the system for classification. This survey provides a wide range of overview for classification of heart rate [9].There is significant variation of waveform in normal and abnormal beats is tested on MIT-BIH arrhythmia database. A study of ECG signal is performing in three stages pre-processing, feature extraction and classifications. Pre-processing detects the abnormalities in ECG signals and decomposition is performed by wavelet transform. Feature vector is extracted from these with normalized energy and entropy. Classification of abnormal signals from normal signal is perform by using fuzzy logic control and achieved only 97% sensitivity for AF [8].

In [7] rough set (RS) and quantum neural network (QNN) are used to recognize ECG signals. In pre-processing rough set (RS) is a mathematical approach and used for extracting features from decion table through a set of reduction and decision rule. Quantum neural network is used to decompose information into corresponding classes.QNN is better than BP and RBF network.QNN enhance classification performance on prior stage of attribute reduction based on rough set theory.

In [26] developed software based tool having algorithm works in three stages pre-processing, feature extraction and classification. For feature extraction use discrete wavelet transform with orthonormal dyadic discrete Wavelets are associated with scaling functions. Arrhythmia features are classified on average 8 intervals PR, RR intervals and QRS widths and they state decision rules for its classification e.g. for Bradycardia if (QRS = = 0.11&&PR>0 && abnormal beat s= 0&&PR<0.2) algorithm reduce accuracy due to absent of separate analog, digital denoising filters.

In [27] proposed algorithm have KDD technique for feature extraction, MIT-BIH ECG database is used. The Multivariate Maximal Time Series Motif detection is the important method in knowledge discovery in this proposed work. Time Series Motifs are the frequently occurring patterns in the discredited Time Series Signal and it integrate tree structure and support based mining for feature extraction. Naïve Bayes Classifier is used for Final Frequent classification and prediction in abnormal and normal signal of ECG. Bayes classifiers have high accuracy and speed when applied to large databases. Naïve Bayes classifiers differentiate each class using the effect of an attributes with it achieves the accuracy of 93.33%.

4 CONCLUSION

ECG i.e. Electrocardiogram is the most common and easily accessible bioelectric signal, which records electrical activity of heart against time and provides doctors with reasonable amount of accurate data regarding condition of heart of patient. Many cardiac symptoms are visible as part of distortions in the Electrocardiogram (ECG). In general ECG related diagnoses are carried out by the medical practitioners manually. The major task is to diagnose condition of heart by analyzing each heart beat and corelating the distortions that are found therein with various heart diseases or cardiac symptoms. As abnormal heart beats can occur randomly at any moment it becomes very difficult and time-consuming to analyze say a 24 hour ECG signal, as it may contain hundreds of thousands of heart beats. Hence it's desirable to automate the entire process of heart beat classification and also preferably diagnose it more accurately. This paper reviews about the different approaches used for ECG signal classification. Abnormal electrical activity of human heart indicates Cardiac arrhythmia, so it needs to identify automatically for analysis and treatment purpose. This paper gives overview of noise removal, waveform detection and classification of heart beats rate in QRS complex. Some existing system have limitation regards heart beat rate interpretation of ECG classification, limitation are accuracy,

removal of noise, slow rate of features extractions and peak detection in ECG signal. The feature works can be done in natural sense prepossessing and prediction based classification.

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