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A COMPARITIVE STUDY ON CLASSIFICATION OF ECG USING SOFT COMPUTING

I. S. Siva Rao[1], T. Srinivasa Rao[2]
[1]*Associate Professor, Department of CSE, Raghu Engineering College, Visakhapatnam, (AP), India*
[2]*Associate Professor, Department of CSE, GIT, GITAM University, Visakhapatnam, (AP), India*

Abstract
Electrocardiogram (ECG) signal is a graph to identify heart disease. Cardiac Arrhythmia is analyzed based on beat recognition, cluster and classification. The noise can be eliminated and features are extracted by using several methods. Discrete wavelet transform (DWT) based algorithms, Discrete cosine transform (DCT) are used to get the features. QRS complexes and RR intervals are extracted based on these algorithms. Extracted features are classified by using Statistical analysis, Classification and Regression Tree (CART), Multilayer Perceptron Neural Network (MLP-NN). MIT-BIH arrhythmia database is used to get the experimental result. Comparison is done for all different analysis to get the accurate result for fast diagnosis.
Keywords: *Cardiac Arrhythmia, Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Electrocardiograms (ECG), QRS Detection, RR Waves, Neural Network.*

1. INTRODUCTION

Electrocardiogram (ECG) is a pictorial form to monitor heartbeat so as to identify heart disease. There are several techniques to analyze the heart disease. Cardiac Arrhythmia is the scientific term of abnormality[2]. Cardiac Arrhythmia is analyzed based on beat recognition, cluster and classification. The noise can be eliminated and features are extracted by using several methods. QRS detection and R-R intervals are the important points in the ECG analysis to diagnosis of heart disease A typical ECG waveform is shown in Fig.1.

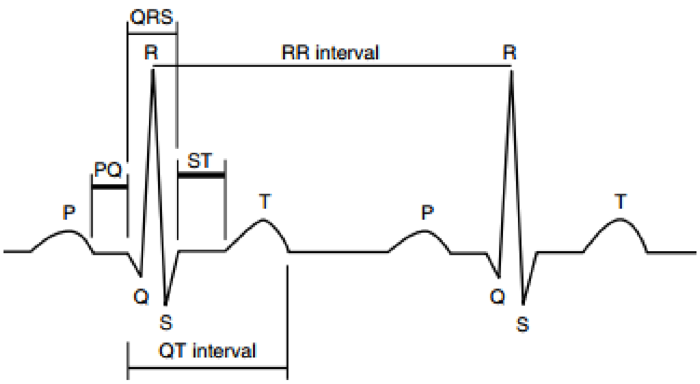

Fig.1. Normal ECG of human heart

The QRS detection algorithm generally consists of pre-processing and decision which include filtering and location of QRS complexes in the ECG signal. The comparison is done between the QRS detection proposed by Pan-Tompkins algorithm [3] and the author proposed algorithm. In this paper the author has used several statistical parameters which integrates the multi-wavelet transform and Pan-Tomskins method. The multi-wavelet transform used in this work are Haar wavelet, Daubechies wavelet, Bior 3.5 wavelet etc to improve the precision of the feature. The parameters like uniformity, entropy,etc., to analyze ECG signal statistically.

2. RELATED WORK

Yun-Chi Yeh et.al., [5] analyzed ECG signal using cluster analysis method, in which the QRS waveform is extracted, and in this method the analysis is done to classify the normal and abnormal heartbeat. Suranai Poungponsria et.al. [4], used approach of combination of discrete wavelet transform and artificial neural network. Wavelet transform decomposes the ECG signal and the noise is removed then artificial neural network is implemented. Indu Saini et.al, [6] has implemented a KNN algorithm as a classifier for detection of QRS complex. Deboleena,et.al [7], has presented an algorithm for detection of R-peak. Hari

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Mohan Rai, et.al, [8], used three classification methods. They are (a) Back Propagation Network (BPN), (b) Feed Forward Network (FFN) and (c) Multilayered Perceptron (MLP). Faezipour, et al., [9] has presented a repetition-detection concept in a patient-adaptive cardiac profiling system, where a wavelet-based beat-detection mechanism first extracts fiducial ECG points following which a new local ECG beat classifier profiles patients normal cardiac behavior. Beat detection is a hybrid of Pan and Tompkins algorithm and wavelet analysis approach. Experiments were undertaken on a MIT-BIH arrhythmia database proving that this system was able to detect beats with 99.5% accuracy and identify abnormalities with 97.42% accuracy.

3. METHODOLOGY

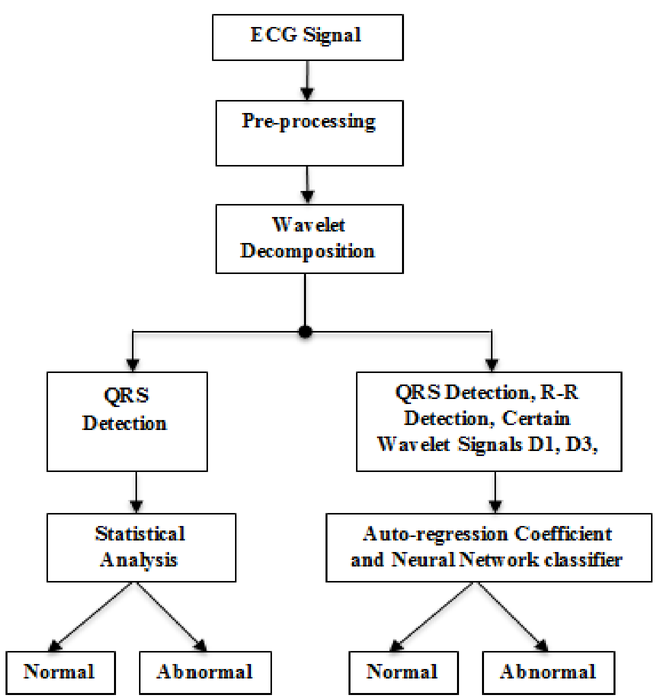

Fig.2. Flow chart represents methodology

3.1 ECG ABNORMALITY: ECG abnormality represents the diagnosis of the Heart Attack, which occurs due to blocks in the blood vessels. The uneven electrical system in heart is known as arrhythmia. They can cause the heart to beat very fast (Tachycardia) or very slow (Bradycardia), or unexpectedly (Atrial fibrillation). There are different types of heart diseases. Table -1 shows the characteristics and various abnormalities of heart disease.

Table-1: Various abnormalities and their characteristic

Sl No.	NAME OF ABNORMALITY	CHARACTERISTIC FEATURE
1	Dextrocardia	Inverted P-wave
2	Tachycardia	R-R interval < 0.6 s
3	Bradycardia	R-R interval > 1 s
4	Hyperkalemia	Tall T-wave and absence of P-wave
5	Myocardial ischaemia	Inverted T-wave
6	Hypercalcaemia	QRS interval < 0.1 s
7	Sinoatrial block	Complete drop out of a cardiac cycle
8	Sudden cardiac death	Irregular ECG
9	Atrial fibrillation	Absence of P wave
10	Ventricular Fibrillation	Highly oscillated ECG

The ECG datasets is taken for training and testing from the Massachusetts Institute of Technology/Beth Israel Hospital (MIT-BIH) arrhythmia database [3], for evaluating the performance of the classifiers. Cardiac Arrhythmia classification includes LBBB (Left Bundle Branch Block), RBBB (Right Bundle Branch Block) and normal beats. Each ECG signal have five distinct points (P, Q, R, S and T) used for ECG interpretation. The ECG data base is taken and pre-processed and filtered to remove noise. Wavelet Decomposition is used to analyze the features.

3.2 QRS DETECTION: In this present work, two procedures were implemented to compare with Pan-Tompkins algorithm and proposed algorithm. The first is Pan-Tompkins algorithm, in which a real-time QRS

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detection algorithm of typical cardiac signal is proposed which consists of LPF, HPF and operators to perform a method which consists of adaptive threshold operations with differentiation, integration, etc.[3]. In the proposed algorithm a multi-wavelet transform used statistically to improve the precision of the feature. The normalized statistical values extracted from each wavelet sub-band can be computed by the following equations [2]:

$$\text{Variance(V)}= \sum_{i=1}^{L-1} (z_i - m)^2 p(z_i)/(L-1)^2 \quad (1)$$

$$\text{Energy}(E_n)= \sum_{i=0}^{L-1} (z_i - m)^3 p(z_i)/(L-1)^2 \quad (2)$$

$$\text{Uniformity (U)} = \sum_{i=0}^{L-1} p^2(z_i) \quad (3)$$

$$\text{Entropy}(E_y) = -\sum_{i=0}^{L-1} p(z_i)\, log_2\, p(z_i) \quad (4)$$

where *zi* is discrete values and *p* (*zi*) is probability of each discrete value and , *i=0,1,2,-----,L-1* is the discrete levels. *L* is the number of levels;

$$m = \sum_{i=0}^{L-1} z_i p(z_i) \text{ is the mean} \quad (5)$$

Many algorithms were proposed for feature extraction from ECG signals. In the second procedure we have integrated QRS detection, R-R peak and several wavelets and statistically auto-regression is done and that is applied to the neural network to get the output as normal signal or abnormal signal.

4. RESULTS:

The results of the proposed algorithm for the record 100 are shown in the figure 3.

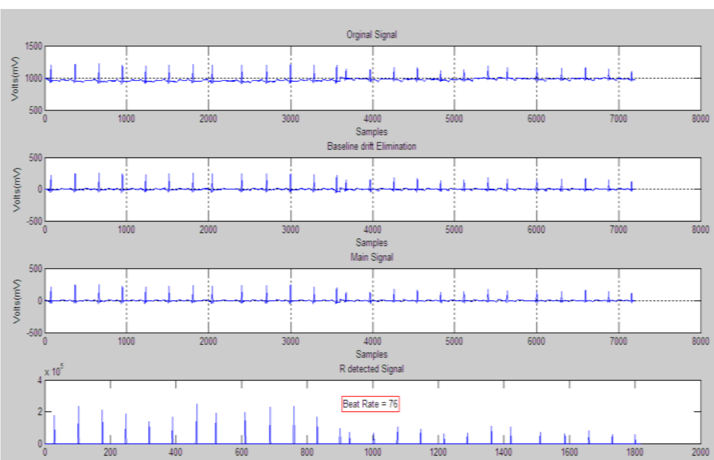

Fig.3. Results of the proposed algorithm for record 100

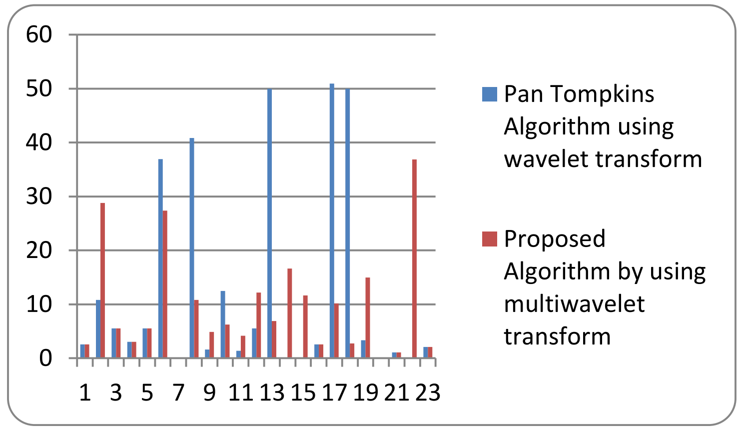

Fig.4. Comparison graph to show Error variation of Pan-Tompkin method and proposed algorithm

The Comparison graph is shown in the figure 4 to represent the Error variation of Pan-Tompkins method and proposed algorithm. The Pan-Tompskin algorithm and the proposed algorithm are compared. The mean percentage error of the Pan-Tompskin algorithm is 12.43% and the proposed algorithm is 9.39%. In this first procedure the proposed algorithm the multi-wavelet transform is incorporated and so the error is very less compared to the previous method.

In the second procedure auto-regression coefficient is implemented by integrating QRS detection, R-R peak and several wavelets and it is applied to the neural network to show the accurate result and identify sensibly the output as normal signal or abnormal signal.

The peaks in ECG such as RR interval, ST interval, QRS interval and QT interval are the points to classify arrhythmia. The performance analysis of soft computing techniques for classifying cardiac arrhythmia using Radial Basis Function (RBF), Support Vector Machine (SVM) and Multilayer Perceptron Neural Network (MLP-NN) are included. Experiments were conducted on the MIT-BIH arrhythmia database and features are extracted from ECG data by integrating Discrete Cosine Transform (DCT) and (DWT) to compute the RR interval. Cardiac arrhythmias classification includes artificial immune recognition system with fuzzy weighted, neural networks, fuzzy neural networks, wavelet

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transforms, combined wavelet transformation, Bayesian classifiers, support vector machines, and Markov models.

Table-2: Detection of Fiducial Points by several Algorithms

S No	Detection of Fiducial Points by several Algorithms	Error%
1	Pan-tompskin's Algorithm with wavelet transforms	6.75%
2	Daubechies, Haar Wavelet	8%
3	Daubechies coefficient	7%
4	Haar coefficient	15%
5	Combined Auto regression coefficient	2.9%
6	Probabilistic Neural Network	0.96%

Fig 5: Comparison of Error Percentage when Pan-Tomkins, Wavelet transforms, Multi-Wavelets, Auto-regression and Neural network are used

Table 2 indicates the percentage error obtained while detecting the fiducial points by using several algorithms. With this table we can understand that the auto-regression model and the neural network implementation is more efficient than any other method. Figure 5 shows all the classification methods to identify the error and to show which method is more efficient. Therefore it is obvious that the Neural network implementation is more efficient than any other technique.

5 CONCLUSION: In this paper the author has discussed about the study of the classification of the ECG using integration of multi-wavelet transforms, auto regression model and implementation of Neural network based classification which shows the very low error percentage when it is implemented through the probabilistic neural network which is very efficient soft computing approach.

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Author' Profile

Mr. I.S Siva Rao has completed his M.Tech in Computer Science and Technology from Andhra University. He is working as faculty member in the Department of CSE, Raghu Engineering College, Visakhapatnam. He has 15 years of teaching experience. Presently pursing Ph.D. in computer Science and Engineering from GITAM University.

Dr T.Srinivasa Rao, has received his Doctoral degree in Computer Science and Engineering from Andhra University. He is working as Associate Professor in GITAM University, Visakhapatnam. He has 17 years of teaching experience.