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Classification of ECG Signal using Artificial Neural Network

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Abstract: ***Electrocardiogram (ECG) is one of the significant investigative tool used in determining the health condition of heart. The raise in number of heart patients has necessitated a technique for automatic determination of diverse abnormalities of heart for lessening the pressure on the specialists or sharing their work load. The work presented in this paper facilitates in generating a computer based system that assists in categorizing the ECG signals. Artificial Neural Network (ANN) is been used for the classification of the signal. The various steps used for the determination of type of ECG signal are preprocessing, Feature extraction & selection and classification. The considered neural network is used to classify the six categories of arrhythmias named Normal Sinus, Right Bundle Branch Block (RBBB), Atrial Premature Beat (APB), Left Bundle Branch Block (LBBB), Arterial fibrillation, PVC. The simulation is done in MATLAB. The obtained results shows that the proposed classifier shows the enhanced performance sensitivity 95%, Specificity99% and classification accuracy 98%. This work provides the comparative analysis of the performance of proposed classifier with KNN, ANFIS and Naive Bias. The results shows the performance of proposed technique is better than other techniques.***

Keywords: ***Electrocardiogram (ECG), Right Bundle Branch Block (RBBB), Premature Beat (APB), Left Bundle Branch Block (LBBB), Artificial Neural Network (ANN)***

I. INTRODUCTION

Human's heart activity can be measured with the help of Electrocardiogram (ECG). It can be used to determine various heart conditions as these signals encompasses lots of morbid data regarding patient's heart processes. ECG which discloses activity as well as the rhythm of the heart is a significant non-invasive clinical means for cardiologists to identify various heart diseases. The heart diseases/abnormalities detection in premature stage can extend life and improve the living quality through suitable treatment.

In biomedical signal examination by means of computers, the rudimentary strength is present in signal processing skill as well as modeling practices used for either quantitative or objective examination. Generally the examinations done by human senses can have some perceptual shortcoming for instance, inter-personal difference, faults due to fatigue, inaccuracies triggered by the low frequency of occurrence of assured indication of abnormality, ecological interruption, etc. The elucidation of a signal made by a professional might fluctuate according to the level of understanding and proficiency of the psychoanalyst. These kinds of analysis mostly are personal. Whereas the analysis based on use of computer has the potential to enhance impartiality to the clarification of the knowledgeable. Hence, the diagnostic sureness and accuracy of the skilled one can be improved. This tactic could be termed as computer assisted analysis.

Instinctive recognition assists in the analysis as well as accelerates the specialist's job. It's particularly helpful in the course of long-term observing electrocardiography (ECG) based observing structures. Investigation of the transcript got for a span of weeks or days might be copious laborious if completed physically. Hence, an automated detection system acutely dwindle the passing time.

The various kinds of heart arrhythmias detection can be done by performing ECG signals analysis. P wave, QRS complexes and T wave are the component of ECG signal. Usually Experts make use of the time duration and amplitude of these waves to perform manual analysis of ECG signal [2]. This kind of analysis is a very tiresome and time-consuming because of the enormous extent of data and there are chances of missing very vital information by the analyst [2]. Hence, the development of a computer based system that categorizes ECG signals, is very important for improving the ECG analysis techniques. Various techniques have been suggested for categorization of ECG heartbeat based on the number of features mined from the ECG signals [3]. The main aim of feature extraction stage is determination of small set of features that allows efficient classification. Without training as well as testing the analyst cannot do the assessment of performance the classifier [3]. So, selection of features is an important process which encompasses training various feature sets until optimum classification performance is attained [3].

In this paper neural network based classifier is proposed for the classification of six types of heart conditions namely, left bundle branch block (LBBB), NSR right bundle branch block (RBBB), atrial premature beat (APB), AFIB and PVC.

II. METHEDOLOGY

The proposed methodology for ECG categorization is presented in figure 1 given beneath.

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Initial phase of the erected method involves preprocessing of the signal. Confiscating base line wander effect as well as noise from the raw data are accomplished in this pace. It consists of three subparts that is use of BPF, NF and decomposition of signal.

Followed by the stage of preprocessing the succeeding pace is extraction of features from the preprocessed signal. In the pace, WPD's i.e. wavelet packet decomposition's higher order statistics coefficients, statistic features as well as frequency domain features are extracted. The relevant time–amplitude information of ECG signal is extracted by using the wavelet transform. Due to the smoothing feature of Discrete Wavelet Transform, it is well suited for detection of changes happened in the ECG signals. Then the final step is classification of the signal by means of the selected features of the signal.

A. Preprocessing

This is the first step involved in the complete system flow. As the ECG signal will be contaminated with noise and artifact effects like baseline drift, noise due to muscle movement etc. so the signals need to be processed for the removal of noise from the signal. So in the first step of preprocessing of the signal is filtered to get the undesirable noise free signal. Filtering of ECG signal is done using a band pass filter within range of 0.05HZ till 100Hz to eradicate the gesture artifact, baseline wander and notch filter of 60Hz is used to eradicate power line noise.

Removal of power-line frequency out of the median filtered ECG is done through a notch filter. Database records have power line interference in the range of 50-60 HZ.

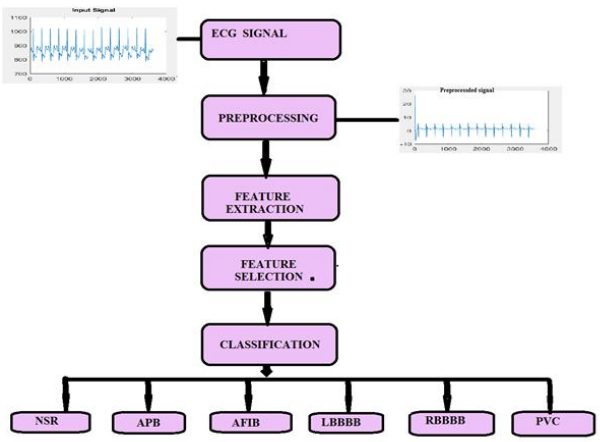

Fig 1: Block Diagram for Classification Methodology

B. Extraction of Features

Extraction of the information required for classification into individual sets is done next to signal preprocessing step. The process is called feature extraction, and represents an important step in ECG data processing. Feature extraction can be defined as automatic identification of several descriptive features of signals. Every segment acquired by signal segmentation can be depicted by its extracted features. Discrete wavelet transform is used to extract features from the signal. The original signal x(t) from the discrete signal x(i)which is first passed through a high-pass filter g(i) and low-pass filter h(i). Filtering followed by sub-sampling constitutes one level of decomposition and can be expressed as

$d1[k]=\sum n\ x(i).g[2k-i]$ ----------1

$a\ 1\ [k]=\sum n\ x(i).h[2k-i]$ ----------2

d1k-detail coefficient, a1k-approximate coefficient at translation k, which are outputs of high pass and low pass filter. An ECG signal characterization can be done by the distribution of the amplitude as well as its moments.

C. Classification

This is the concluding step of this processing technique. Various types of neural network have been used by number of researchers for the classification purpose of ECG signals. Artificial neural networks has been used for the classification purpose in this work, as ANNs are self-adaptive, data driven, fast, non-linear, as well as accurate. It is scalable as well as robust to noise. ANN have various benefits to list a few : 1) By using activation functions such as sigmoid it gives non-linear mapping amongst inputs as well as outputs for solving non-linear problem like categorization of ECG signals. 2) It is able get the results that are analogous or improved than statistical or deterministic methods. The performance of statistical approaches is virtuous for linear problems however can't produce virtuous results in case of non-linear problems since statistical methods settled on basis of the hypothesis of given linear time series. 3) The inferior frequencies of the ECG can be adaptively modeled by ANN which are characteristically non-linear. 4) ANN confiscates time varying and nonlinear noise physiognomies of ECG signal [5].

The different measures such as specificity, sensitivity and accuracy have been utilized for measuring performance of given classification method. In this work the classification performance of different classifiers ANN, KNN and NAVIE BAYES is compared. The obtained results indicates that ANN's performance is better compared to other two classifiers.

III. PERFORMANCE METRICS

Some diagnostic method uses "0" or "1" to give result that indicates "negative" or "positive". The judgement made will be possibly "incorrect" or "correct". Hence for every judgement two kinds of replies are there. In accordance with two-class case, four potential circumstances are there as a judgement (Gibbons et al., 1997). The illustration is categorized as positive if it is positive and will be allotted true positive (TP); the illustration will be assigned false negative (FN) if categorized as negative. If the situation is negative and is categorized as negative at that time it will be allocated as True Negative(TN); if the illustration is negative and categorized as positive, it will be considered as false positive (FP).

1. Accuracy of classification

Classification accuracy can be represented as the relation between the number of correctly classified cases TP and TN divided by the total number of cases N. [4]

$Accuracy=$

$(TP+TN)/N$----------3

2. Sensitivity

The proportion amongst the number of positive judgements categorized correctly by means of recognition system and total number of positive judgements done by skilled professional is represented as sensitivity. It gives the ratio of properly categorized abnormal patterns to abnormal pattern. Sensitivity mentions the percentage of appropriately classified positive that is equal to TP divided by the sum of TP and FN. Sensitivity may be referred as a True Positive Rate. [41]

$Sensitivity$= (TP)/$(TP+FN)$---------- 4

3. Specificity

Specificity is portrayed as the ratio amongst appropriately produced negative judgements total number by the recognition system and negative judgements total number done by the professional. Specificity denotes to the proportion of correctly classified negative and is equal to the ratio of TN to the sum of TN and FP. False Positive Rate equals (100-specificity).

$Specificity$= (TN)/ $(FP+TN)$ ----------5

4. Precision

It is also known as positive predictive value (PPV), is the fraction of retrieved instances that are relevant

PPV=TP/ (TP+FP) ----------6

IV. RESULTS

The experimental results of ECG analysis have been obtained by means of MATLAB programming. The ECG data used for the analysis is taken from MIT-BIH database. In this 80% data is used for training the network and 20% is used for testing. The classification of the signal is done with the help of artificial neural network .The following figures shows the classification result for the signal. The selected signal is preprocessed using band-pass and notch filter then from the preprocessed signal features are extracted followed to this among extracted features few features are selected as an input to the classifier.

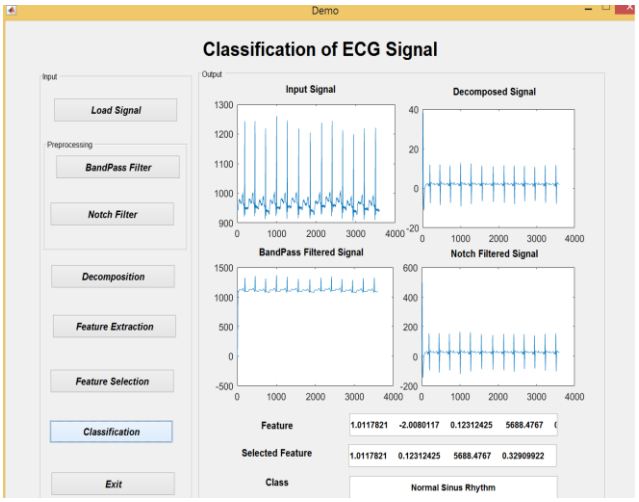

Fig2. ECG signal identified as Normal

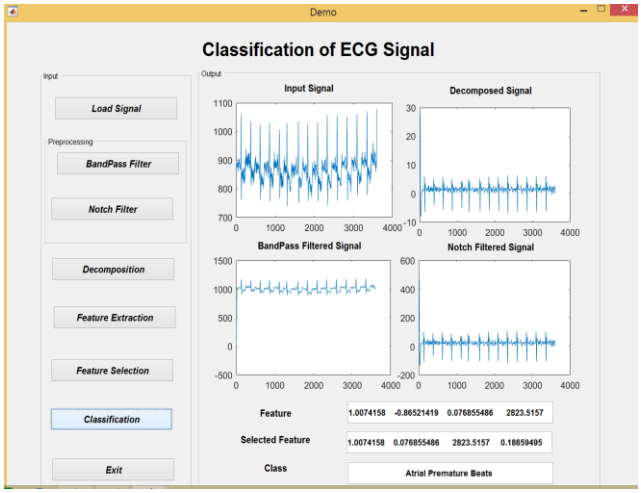

Fig 3. ECG signal identified as APB

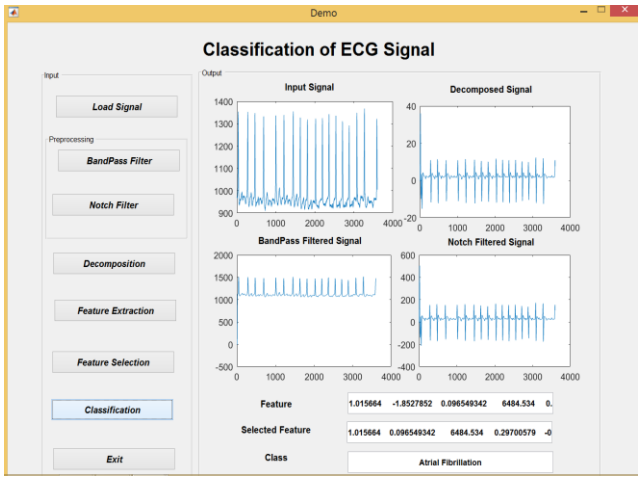

Fig4. ECG signal identified as AFIB

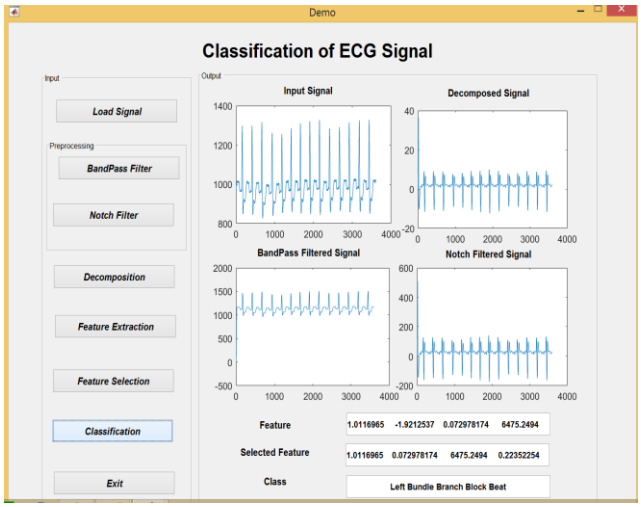

Fig 5. ECG signal identified as LBBB

The performance of different classifiers is measured with the help of different measures. The following table give the values of different performance measure for the classifiers ANN, KNN, NB, ANFIS.

Table 1. Comparison of Performance measures of different classifier

Classifier\ Class	SEN	SPEC	ACC	PRECISION
ANN	0.950617	0.990123	0.983539	0.950617284
KNN	0.876543	0.975309	0.958848	0.87654321
NB	0.654321	0.930864	0.884774	0.654320988
ANFIS	0.691358	0.938272	0.897119	0.691358025

V. CONCLUSION

ECG signals is the most fundamental signal that gives significant data about the wellbeing and working of the heart. Automatic investigation and classification of ECG signals is a significant in different clinical applications as they can help doctors to analyze aberrations and illnesses based on these signs. In any case, precise classification of these biomedical signs is challenging because of the disorderly nature and intricacy of these signs. The work presented here is concentrated on evolving classification techniques for precise recognition of ECG signal. In the suggested work the ANN is used to perform the task of classification of the ECG signals. Classification of ECG is discussed with the different steps involved in it. In preprocessing the filtering technique is used to remove the noise in the feature extraction phase different features like skewness, kurtosis, mean, entropy-based features have been extracted. The next step is the classification, for classification artificial neural network is used. Performance of ANN is compared with other methods of classification that is K-NN, Naïve Bias and ANFIS. The performance of all the classifiers that is ANN, Naive Bias, ANFIS and KNN is compared using the parameters precision, Recall, F-Measure, Accuracy, Sensitivity and obtained results shows that the performance of ANN is better in comparison with other classifiers. The proposed classifier shows the enhanced performance sensitivity 95%, Specificity99% and classification accuracy 98%.

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