A SCHEME FOR ECG INFORMATION UTILIZATION FOR DETECTING AND CLASSIFYING HUMAN HEALTH

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Abstract: - Cardio vascular diseases or CVDs are considered as one of the most common diseases presently. There are number of factors such as, diabetes, cholesterol, high BP etc. that are responsible for these cardio vascular diseases. Therefore, there is a need of identifying heart diseases at early stages so that the life of the patient can be saved. Electrocardiogram (ECG) plays an important role in determining different heart diseases, such as irregular pulse rhythm, Cardiac arrhythmia etc. Cardiac arrhythmia is a condition when the heartbeat is either too slow or too fast. From the literature survey conducted, it is analyzed that number of approaches like ANN were already proposed by various researchers, but those models were complex and inefficient. Hence, need for developing a model with reduced complexity, increased efficiency and accuracy arises. In this research, a novel technique is presented to detect the regularity of the heart beat in a human by combining the classical ANN system with Fuzzy Inference System, to overcome the limitations of the conventional ANN model. In addition to this Wavelet-based feature extraction method is applied to the data that extract the informative features from the ECG signal that are used for subsequent analysis. Eventually the simulation of the model is carried out in MATLAB software in terms of accuracy of the model. The results showed that the proposed ANFIS based model outperformed the efficacy of existing heartbeat detection model.

Keywords: - Heart disease detection, biomedical applications, artificial neural network, ECG signal, prediction system, etc.

1. INTRODUCTION

Most of the deaths caused worldwide are due to heart disease i.e. cardiovascular diseases. In average 235 deaths per 100,000 humans i.e. 31% of the world's deaths are caused by the heart disease. Some of the main causes of the CVD's are intake of excess sugar (diabetes), mal-nutrition or improper diet, hypertension, drugs, smoke, no physical exercise, alcohol intake. Other reasons of the heart attack are due to blockage of the blood as well as oxygen in the artery of the coronary. If these issues could not be treated within the duration, then it could produce harmful effects on the heart [1]. In India CVD mortality is roughly 272 per 100 000. WHO reports that, with the concern focuses of CVD's [2], India will lose $237 billion in productivity losses. A crucial diagnostic method for assessing heart conditions is the electrocardiogram (ECG). In the past 4 decades, electrocardiogram waveform analysis has been one of the crucial research methods in the processing of biomedical signals. During various stages of the heart cycle, the electrical activity is recorded with the help of ECG. The ECG rhythm can be determined through necessary information provided by PQRS and T complexes about the R wave. The PQRS and T-waves for individual cardiac cycle are a standard ECG tracing process. [3]. The P-Q-R-S-T sequences reflect the repeated process of electrical impulses in the heart. Because of the frequency band range i.e. 0.5 Hz to 150 Hz, the signal of the ECG is quite susceptible to noise [4]. Owing to disturbances from different noise sources and artifacts, the pulse perceptions of quality varies during recording. It is therefore a difficult task to obtain valuable information for the efficient identification of cardiac arrythmia from the ECG waveform. The main noise factors in ECG are: power line interferences, baseline wander, muscle contraction (EMG) etc. The production of modern-performance and accurate assessment of ECG waveform has played an essential part in technology of the computer in recent years. The biology demonstrates dynamic and evaluation of the non-linear, which in time-series examine a crucial issue [5]. Fig.1 shows the key steps for ECG signal processing.

- ECG waveform noise removal utilizing pre-processing filters.
- Identification of dynamic QRS & ECG waveform attributes points.
- Set important feature extraction & implementation.
- Heart rhythm description.

The detection of different heart abnormalities through ECG signals undergoes various stages, these are: signal acquisition, pre-processing, feature extraction, feature selection and classification. These phases are further explained in below:

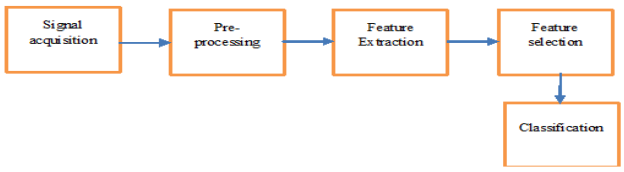

Fig.1 Block diagram of ECG beat classification system

In the first stage, the heart acts as the rhythmic organ that

pumps blood across the entire body. The signals are recorded or analyzed by electrodes and other mechanisms. In the pre-processing stage, any noise (50-60 Hz) that is present in the signal is absorbed or eliminated with the help of filters. Over the last 10 years, several wavelet-based techniques are often used to minimize noise, as they maintain ECG waveform characteristics and prevent losses of their main physiological information. The feature extraction process is crucial to the success of the cardiovascular categorization using the ECG waveform. Any pulse rate information being used to distinguish its category may also be termed as a property. Feature selection techniques can have different advantages for different classifiers, including improved classification model's generalization power & minimizing device costs as they use functionalities that are less available in order to design the process result. Finally, with the help of artificial intelligence technology along with machine learning & data mining functions for heart-beating identification, models can be built from such information when the set of characteristics was already identified from the pulses. In order to detect different heart abnormalities, a number of ECG methods were proposed by various researchers which are discussed in the next section

2. LITERATURESURVEY

A lot of researchers have been done on ECG heartbeat abnormalities using AI. Among them some of works are analyzed here; E. Al-Masri [6], presented an alternative based on the neural network that could identify pulse abnormalities, such that the necessary functional set can be minimized. Pooja sharma, et al. [7], analyzed the appropriate ECG arrhythmias with a hybrid Support vector machine & Artificial Neural Network classification system that demonstrated repeatedly excellent model recognition efficiency. Eduardo José da S.Luz, et al. [8], discussed the new ECG automatic anomalies identification methodologies by introducing the ECG waveform pre-processing mechanism, the cardiovascular segmentation strategies as well as the approaches often used to classify features or the learning based algorithms. H. Shi, et al. [9], proposed an automatic description of the pulse of arrythmia by a system dependent on the convolutional neural network. CNN did not require significant element extractions or classification steps relative to traditional machine learning approaches. F. A. Elhaj, et al. [10], suggested the classification of the hybrid method for the identification of arrhythmias by pulse detection with the Bayesian & Intense Learning Machines method. G.Sannino, G.De Pietro [11], proposed a new profound teaching strategy to the ECG pulse classification based on the MIT/BIH Arrhythmia records and their findings were correlated with academic researches. K. Waseem, et al. [12], analyzed the appropriateness of optimization algorithm, with a minimal user interference, to distinguish a regular ECG with an anomalous one. Z. Wu, et al. [13], proposed the technique for controlling different rhythms dependent on duration & genetic algorithms of the convolution. N. K. Dewangan and S. P. Shukla [14], artificial neural network (ANN) based classifier is developed, where discrete wavelet transforms (DWT) is used for preprocessing and feature extraction purposes and neural network designed is used to classify five types of arrhythmias namely Left Bundle Branch Block (LBBB), Right Bundle Branch Block (RBBB), Paced Beat (PB), Atrial Premature Beat (APB) and First-degree AV Block (AVB) beats apart from normal (N) beats. YoungKyoo Jung and W. J. Tompkins [15], developed an algorithm premised on waves to recognize and identify 4 kinds of arrhythmia ventricular. The authors also implemented & compared the methodology utilizing 4 wavelets. E. Ramya, et al. [16], provide an irregular heart beat control, which typically uses the topography of electrocardiographs as well as a radial gradient. The methods for detecting & distinguishing P-Q-R-S-T signals were typically evolved.

From literature study it is analyzed that artificial neural network is gaining enough interest from researchers to achieve improved detection rate. From the study it was analyzed that the conventional artificial neural network is performing effectively with respect to other approach but still it has few areas where improvements are possible. The major drawbacks those are found in traditional approaches with ANN are as Neural networks can only be utilized when huge training dataset is available. As most of the neural network architecture are black boxes that means their final state cannot be interpreted in terms of rules. Furthermore, the learning process itself can take long time and that too comes with no guarantee of success, etc. Moreover, the classical classification models also face the issue related to features from ECG signals. The traditional techniques used for the feature extraction calculates the PQRST points from the ECG wave. However, these features were not easy to locate in the received signal thus it become difficult to predict the current state of the patient and it can lead to even the death of a person. Inspired from these finding the proposed model in this paper will overcome the issue related to feature extraction model as well as provide a system that will resolve the issue related to conventional neural network. The detail description of the proposed scheme is given in next section.

3. PROPOSED WORK

In order to overcome the issue related to conventional approaches, this paper propose a model that is based on the neuro-fuzzy network to detect the ECG heartbeat abnormalities with high accuracy. The reason to select the neuro-fuzzy over conventional neural network is properties those are judicious integration of the merits of neural and fuzzy logic, which enables one to build more intelligent decision-making systems and can be used for detecting the abnormalities accurately. This incorporates the generic advantages of artificial neural networks like massive parallelism, robustness, and learning in data-rich environments into the system. The modeling of imprecise

and qualitative knowledge, as well as the transmission of uncertainty, is possible through the use of fuzzy logic. The basic idea of combining fuzzy systems and neural networks is to design an architecture that uses a fuzzy system to represent knowledge in an interpretable manner and the learning ability of a neural network to optimize its parameters. Furthermore, an additional improvement that is presented in the proposed scheme is based on feature extraction phase. Traditional PQRST point localization is replaced with the wavelet feature extraction techniques, further the proposed feature model will extract the features in terms of mean, standard deviation, maximum and minimum amplitude with variance from the extracted wave so as to achieve effective features.

A. Model Design

In our proposed system, neuro-fuzzy network is used to detect the ECG heartbeat more precisely along with the wavelet-based feature extraction technique. The performance of the proposed system is simulated and evaluated in the MATLAB software along with the different parameters. The results obtained from the simulations are than compared with the traditional models.

To start with the simulation, initially the ECG signal from the dataset are read and sampled so as to extract the required information from the signal.

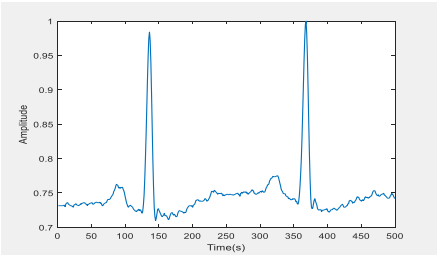

Fig.2 Waveform of ECG

Fig.2 represents the ECG signal of one patient, this signal is sample to 500 samples and graphically represented that shows the values of its amplitude with respect to time. The graph represents that the ECG signal has the value of amplitude varying between 0.7 and 1 for the varying time that ranges from 0 to 500 sec.

B. Feature Extraction

Once the signal is sampled, the next phase in the proposed scheme is to apply the wavelet transformation in order to transform the signal. The transformed signal is then processed to extract the five fundamental coefficients namely mean, variance, standard deviation and Minimum and maximum values of transformed signal along with their three respective membership functions. These membership variables and functions are than used in order to extract features.

C. Wavelet transformation

Wavelet transformation is considered as the best method for non-stationary signals and provides information about the signal time and frequency. Since transforming wavelets has different windows, they are broad at low frequencies and narrow at high frequencies. It is important to use wavelets to handle and compute data in compressed parameters that are often referred to as features. The transformation of a multi-scale wavelet will decompose a signal into many scales. The transforming wavelet is a wavelet convolution with x(t) signal. The original signal is applied to the multi-resolution wavelet transform through a high pass and a low pass filter and approximate and comprehensive signal coefficients are obtained. The specifics are the small, high-frequency and approximate components of the signal that are high-scale, low-frequency. During the study of different frequency bands using DWT it is possible to break up the signal into approximation and detail. Choosing the mother wavelet is very important in wavelet transformations and there is no universal method to pick a specific wavelet function. The signal to be studied depends upon its type. Typically, the signal analyzed that matches the wavelet function is chosen. Thus, with the help of wavelet transformation in our proposed work, enhanced the accuracy of heartbeat detection in ECG.

D. Neuro-fuzzy system explanation in terms of our model

Next phase for proposed system is to initialize the neuro fuzzy classifier, for this the first phase is to define the fuzzy input with respect to feature extracted. In proposed model total number of input features is 5 in count named as mean, std, variance, max and min values, therefore, the classifier's fuzzy system will have 5 membership variable and 1 output. The individual membership variable is having 3 triangular membership functions. And as per the training data the fuzzy is having a sum of 243 rules in it. The fuzzy interface for neuro fuzzy is shown below in Fig.3.

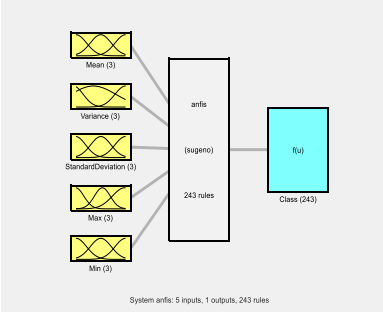

Fig.3 Proposed Fuzzy system with 5 inputs and 1 output

Fig.3 represents the schematic diagram of the proposed ANFIS model, in which five input parameters for the proposed ANFIS system are defined. These parameters are then processed by the Sugeno type of fuzzy model on the basis of 243 rules and then finally produces a single output

f(u). A total of three membership functions called as low, medium and high are available for these parameters. Once the fuzzy system is initialized next part is to define the training parameters of neuro fuzzy. For neuro fuzzy we have considered error goal as 0, initial step size as 0.01 and training epochs as 10. Once the neuro fuzzy system is initialized, the next phase is to analyze and test it, for this we have taken 60% data for training purpose and 40% data for testing purpose. The system was evaluated in terms of the accuracy.

E. Accuracy

Accuracy can be defined as the ratio of total number of correct predictions while detecting heart abnormalities to the total number of predictions, and can be represented as in (1).

$$\text{Accuracy} = \frac{number\ of\ corect\ heart\ abnormalities\ prediction}{total\ number\ of\ ECG\ samples\ for\ testing} \quad (1)$$

F. Dataset

The MIT-BIH database is used in our proposed model. A total of 47 subjects that were studied in the BIH arrhythmia Lab during the year 1975 and 1979 were utilized, to collect a 48 half-hour long two-channel ambulatory ECG data. Out of the 47 samples, 23 were chosen randomly from a set of 4000 samples that's collected from the 24-hour long ECG recordings at Boston's Beth Israel Hospital. Rest of the 25 samples was taken from the same set in order to add few basic but significant arrythmias. The samples were digitized with a 11-bit resolution over a range of 10mV at the rate of 360 samples/sec/channel. The records were analyzed individually by various cardiologists to eliminate the disagreements in order to get the computer readable reference for each heartbeat. Around 110,000 annotations are included in the dataset.

4. RESULTS AND DISCUSSION

The proposed neuro fuzzy model was tested and evaluated in MATLAB software in terms of accuracy. The simulation results are analyzed and compared with the classical approach and are discussed in this chapter.

A. Performance evaluation

The membership function graphs of the input variables of the traditional and the proposed systems are shown in Figure 1.4. The comparative analysis is performed on the proposed neuro fuzzy (ANFIS) approach and conventional BPNN approach in terms of accuracy the results of which are represented in bar graph of the fig.4.

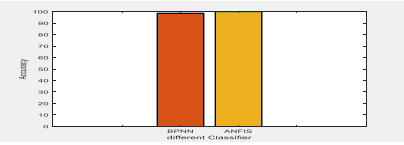

Fig.4 shows the comparative analysis in terms of accuracy

The orange bar in the graph depicts the results of conventional BPNN approach and the yellow bar delineates the result of proposed ANFIS approach. On closely analyzing the graph, it is observed that the accuracy of the proposed approach is higher than the conventional approach and thus, it is more efficient than the conventional one. The value of accuracy obtained for proposed approach and previous approach are mentioned in table 1.

Table 1: Accuracy of different classifiers

Classifiers	**Accuracy (%)**
BPNN	98.70
ANFIS	99.95

The performance of the traditional approach and the proposed approach is calculated in terms of accuracy, which comes out to be 98.70% and 99.95% respectively. The higher accuracy value of the proposed approach proves that it has better performance i.e. can detect the heart diseases with more accuracy as compared to conventional approach.

The distribution of the correctly classified ECG beats using the proposed ANFIS approach is shown as a pie-chart in fig.5.

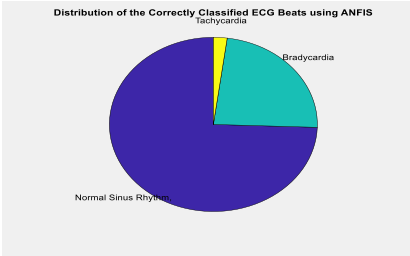

Fig.5: Distribution of correctly classified ECG beats using ANFIS

It shows the classification for three types of arrhythmias i.e. Sinus Rhythm, Bradycardia and Tachycardia. The proposed approach has correct classification rate of 99.95% across all types. This high accuracy thus will help to attain an efficient system for heart disease detection that can detect the abnormalities with high accuracy.

5. CONCLUSION

Cardio vascular diseases are also known as CVDs is one of the major reasons behind the huge number of deaths globally. There are about 1.75 million people who died because of the CVDs in the year 2012 globally. Therefore, it becomes extremely important to detect the heart diseases in early stages. With the help of ECG technique, the CVDs can be detected. But the problem with the available methods is that they do not predict the heart abnormalities accurately. Thus,

it became more prominent to design and develop a model that detects heartbeat abnormalities with high accuracy. From literature study it is observed that various researchers used different classifier for data mining. Amid them, Artificial Neural Network gave better results but it also lacks in offering a high effectiveness due to some limitations. To overcome these issues, we proposed a neuro fuzzy (ANFIS) model which incorporates advanced classifier and a wavelet-based feature extraction technique to reduce the complexity and increase the performance. The results are achieved by performing simulation in MATLAB software. The comparison for conventional classifier (BPNN) and proposed technique is carried out in terms of accuracy. The evaluation showed the validation of proposed model as it is capable of giving high accuracy which accounts to 99.5%. Thus, the proposed model for heart beat detection is effective and robust in terms of determining the regularity of the heartbeat.

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