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Classification of Atrial fibrillation ECG and Malignant Ventricular Arrhythmia ECG using Adaptive Neuro-Fuzzy Interface System

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Abstract--Now a day we have various types of intelligent computing tools such as artificial neural network (ANN) and fuzzy logic approaches are proving to be skillful when applied to a different kind of problems. This paper describes the application of adaptive neuro-fuzzy inference system (ANFIS) model for classification of electrocardiogram (ECG) signals. here we applied tool for detecting the two different type of abnormal ECG signal. Here the designed ANFIS model contained both approaches the neural network adaptive potential approach and the fuzzy logic qualitative approach.The Electrocardiogram (ECG) dynamic and nonlinear signal characteristic requires an accurate and precise detection and recognition system. This paper describes the detection of a MIT-BHI normal Artial Fibrillation ECG signal and MIT-BHI Malignant Ventricular ECG signal based on ANFIS approach. Some conclusions regarding the detection and classification of the abnormal ECG signals is obtained through analysis of the ANFIS. The proposed ANFIS modal gives the 100% accuracy for Artial Fibrillation ECG detection and 80% accuracy for Malignant Ventricular ECG detection. Classification accuracies and the results created by the ANFIS confirmed that the proposed ANFIS model is very efficient in classifying the normal and abnormal ECG signals.

Index Terms-- Adaptive Neuro-Fuzzy Interface System (ANFIS), Electrocardiogram (ECG) ,Artial Fabrillation ,Malignant Ventricular , MIT-BHI database.

1 INTRODUCTION

The problems regarding to Cardiac are increasing day by day. For diagnosis the heart Electrocardiogram (ECG) is the most commonly used test method. Reorganization and treatment of arrhythmias have become one of the cardiac care unit's major functions. Few of the arrhythmias are Ventricular Premature Beats, artial fibrillation a systole, Couplet, Bigeminy, Fusion beats, and the objective of ANFIS is to integrate the best features of fuzzy systems and neural networks. The advantage of fuzzy set is the representation of prior knowledge into a set of constraints to reduce the optimization research space is utilized.[1,2] for getting the best

result toward the unknown and unseen data the size of the training database should be at least as large as the number of modifiable parameters in ANFIS.

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Electrocardiogram (ECG) represents the electrical activity of the heart. When the ECG is abnormal, it is called arrhythmia. Millions of ECGs are taken for the diagnosis of various classes of patients, where ECG can provide a lot of information regarding the abnormality in the concerned patient are analyzed by the physicians and interpreted depending upon their experience. The interpretation may vary by physician to physician. Hence this work is all about the automation and consistency in the analysis of the ECG signals so that they must be diagnosed and interpreted accurately irrespective of the physicians.[3,4] the recorded ECG waveform which is made of distinct electrical depolarization and repolarization patterns of the heart. Any disorder of heart rate or rhythm, or change in the morphological pattern, is an indication of an arrhythmia, which could be detected by analysis of the recorded ECG waveform.

A typical cycle of an ECG is shown in Fig. 1. Physicians first locate such fiduciary points as Q points, R points, and *S* points in the ECG from which they locate the P-complexes, QRS-waves, T-complexes, and U-waves in the ECG. These waves and complexes are defined in Fig. 1. Physicians then interpret the shapes of those waves and complexes. They calculate parameters to determine whether the ECG shows signs of cardiac disease or not. The parameters are the height and the interval of each wave, such as RR interval, PP interval, QT interval, and ST segment (Figure 1).[5]

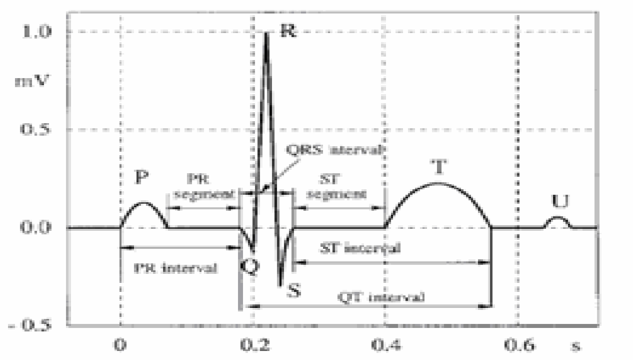

Figure 1 The ECG signal and its different components

In this paper we applied Artial Fibrillation Arrhythmia ECG database and Malignant Ventricular Arrhythmia database, the normal sinus rhythm not only give you an idea about the rhythm is normally generated from the sinus node and wandering in a normal manner in the heart. In most of the research paper single ECG bit taken for analysis, but in our research we have taken the 10 sec complete ECG include of many ECG bit is taken for analysis which has taken a great care in case of heart beat variability. The normal value of heart bit rate depends upon age it is not same for all the normal people, normal heart rate for an infant is 150 beats in one minute maximum, even the heartbeat rate of child of five year age may 100 beats in a minute, the heart rate of adult is slower than the child, it is about 60-80 beats in one minute. In normal sinus rhythm of heart p-waves are pursued after a short gap by a QRS complex followed by a T-wave of ECG the cause of Supraventricular Arrhythmia is a quick heart rhythm of the upper chambers of the heart.

Atrial fibrillation (AF) is an arrhythmia in which electrical activity in the atria is disorganized. Instead of the sinus node providing the normal electrical signals to the atrium, rapid circulating waves of abnormal electrical signals continuously stimulate the atrium. The atrial rate can exceed 400 beats per minute. During AF, electrical signals from the atrium constantly bombard the AV node. The AV node passes a large number of these rapid signals to the ventricles, which beat rapidly and irregularly. The ventricular rate can vary from 50 to 200 per minute, depending on the degree of AV conduction. In fact, the overall rate of the ventricles varies tremendously, depending on the age of the patient, the health of the AV node, and whether medications to slow AV conduction (such as calcium-channel blockers or beta blockers) are present

Ventricular arrhythmias occur more frequently with advancing age, severity of heart disease and ventricular hypertrophy. Malignant ventricular arrhythmias are following forms: out-of-hospital ventricular fibrillation (VF), recurrent sustained ventricular tachycardia in the long QT syndrome. Each condition has a high 1-year mortality rate. Potentially malignant ventricular arrhythmias are ventricular premature complexes (VPCs) of >10 per hour 10 to 16 days after acute infarction and repetitive VPCs. The most malignant arrhythmias occur with severely depressed ventricular function, but VPCs alone have independent prognostic significance. Benign ventricular arrhythmias occur in patients without known heart disease and do not require treatment. The exact effect of frequent and complex VPC in these patients needs further definition.

2 PROPOSED ANFIS:

In this paper we use adaptive Neuro-fuzzy interface tool for training and testing the database, here ANFIS is an adaptive network which uses neural network topology and fuzzy logic together; ANFIS uses the characteristics of both methods. The combination of both methods removes the some disadvantage of both the method.

Actually, ANFIS is like a fuzzy inference system but in ANFIS feed-forward back propagation to minimize the error. Mamdani type and Takagi-Sugeno type is commonly used system in ANFIS .In our analysis, we use zero-order Takagi-Sugeno fuzzy inference system.

The ANFIS first introduced by Jang in 1993, It is a model that maps inputs through input membership Functions (MFs) and associated parameters, and then through output MFs to outputs. The initial membership functions and rules for the fuzzy inference system can be designed by employing human expertise about the target system to be modeled. ANFIS can then purify the fuzzy if–then rules and membership functions to describe the input–output behavior of a complex system. Jang showed that even if human expertise is not available it is possible to intuitively set up practical membership functions and employs the neural training process to generate a set of fuzzy if–then rules that approximate a desired data set.

Five layers are used to create this inference system. Each layer involves several nodes described by node function. The output signals from nodes in the previous layers will be accepted as the input signals in the present layer. After manipulation by the node function in the present layer will be served as input signals for the next layer. Here square nodes, named adaptive nodes, are adopted to represent that the parameter sets in these nodes are adjustable. Whereas, circle nodes, named fixed nodes, are adopted to represent that the parameter sets are fixed in the system. For simplicity to explain the procedure of the ANFIS, we consider two

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inputs *x*, *y* and one output *f* in the fuzzy inference system. And one degree of Sugeno's function is adopted to depict the fuzzy rule.[6-9]

ANFIS gives a powerful tool for data classification. for example:

Rule 1: If x is A1 and y is B1 then f1=a1 x +b1 y + c1
Rule 2: If x is A2 and y is B2 then f2 = a2 x +b2 y + c2.
The given figure 3 is the ANFIS architecture of 5 layer.[6-9]

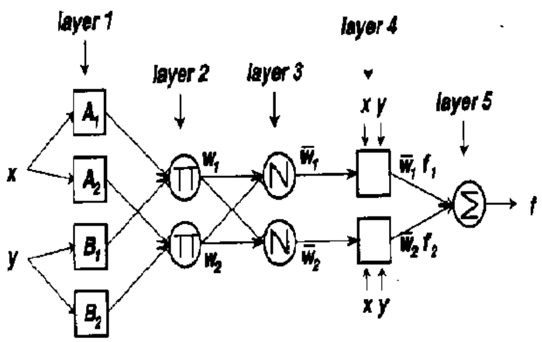
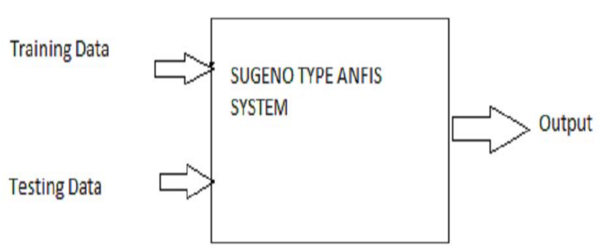


Figure 2 ANFIS Architecture

The block diagram of the ANFIS system is shown in the figure-3, two arrows indicate the training data and testing data that applied to the sugeno type ANFIS system. Training data used for preparing the network architecture and decide the input and output range according to the training function, number of epoch, the method used for optimization and number of membership functions is used for training. After this test data is applied, on the basis of proposed ANFIS network output is determined in the form of number.



ANFIS system for Detection normal and abnormal ECG Signal

Figure 3

The coding sugeno type network is done with the help of book MATLAB "An Introduction with Applications" written by Amos Gilat on MATLAB 7.10.0 (2010a) software.[10]

3 Method Used:

The MIT-BIH Database contains 48 half-hour excerpts of two-channel ambulatory ECG recordings, obtained from 47 subjects studied by the BIH Arrhythmia Laboratory between 1975 and 1979. The recordings of normal sinus ECG (ECG1) database and Supraventricular ECG (ECG1) database were digitized at the rate of 250 samples per second per channel with the resolution of 11-bits over a span of 10 mV.[11]

In our method we use Artial Fibrillation and Malignant Ventricular database, in Artial Fibrillation database we take 20 ECG Signals out of 20 we use 15 in training and 5 in testing. The duration of one ECG is 10 Sec with sampling rate 250 Hz and total sample of an ECG signal is 2500. In Malignant Ventricular database we use 20 ECG Signals out of 20, 15 signal used for training and 5 used for testing. The sampling rate of Malignant Ventricular ECG signal is same as Artial Fibrillation ECG signal.

Sugano type system is used for training and testing, total number of input membership functions used is 4 , total number of output membership functions used is 4,4 num rules is used, input range is [-3875 4405] and output range [0 1]. We use a hybrid method which is a grouping of both least-squares estimation method and back-propagation Method, as an optimization method.

4 Input Data:

The input database is given in the matrix from shown in the table

Name	Total	Training	Testing
Normal Sinus ECG Database	20	15	5
Supraventricular ECG database	20	15	5

From the above table the total 40 ECG signal are used for analysis, out of 40 30 is used for training and remaining 10 used for testing.

Analysis:

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A membership function is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. Gaussian curve built-in membership function, gaussmf, Gaussian membership functions and bell membership functions achieve smoothness, they are unable to specify asymmetric membership functions, which are important in certain applications.[12-13] We applied the above input database to ANFIS tool of MATLAB-2010a , the Gaussian curve built-in membership function is used as an input membership function and output membership function is linear type. There are four membership functions for input and four for output and number of epochs is 20.testing data of both ECGs are given is given in the table.

The symmetric Gaussian function depends on two parameters σ and *c* as given by

$$f(x;\sigma,c)=e^{\frac{-(x-c)^2}{2\sigma^2}}$$

The parameters for gaussmf represent the parameters σ and *c* listed in order in the vector [14].

```
x=0:0.1:10;
y=gaussmf(x,[2 5]);
plot(x,y)
xlabel('gaussmf, P=[2 5]')
```

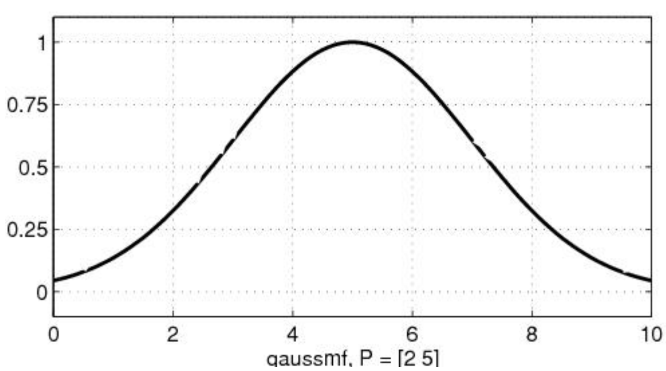

Fig-4 Gaussmf

The figure 5 sugeno type ANFIS system is shown the relation between the input and output there are two input function and two output functions and two rules is used for the training and testing. here f(u) is the function of the output and the figure 6,7 show rule applied for training and testing.

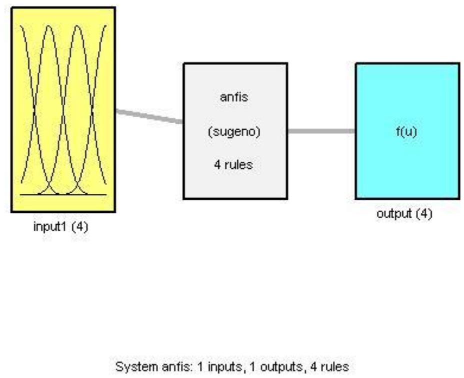

Figure 5 ANFIS system

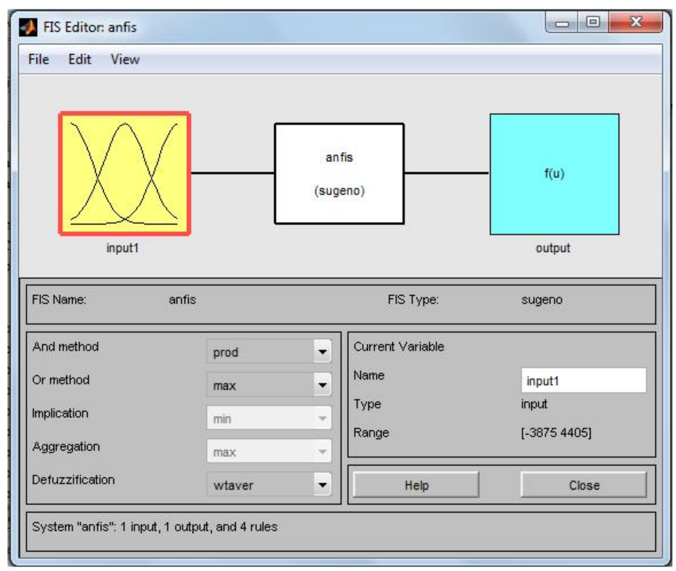

Figure 6 ANFIS FIS editor

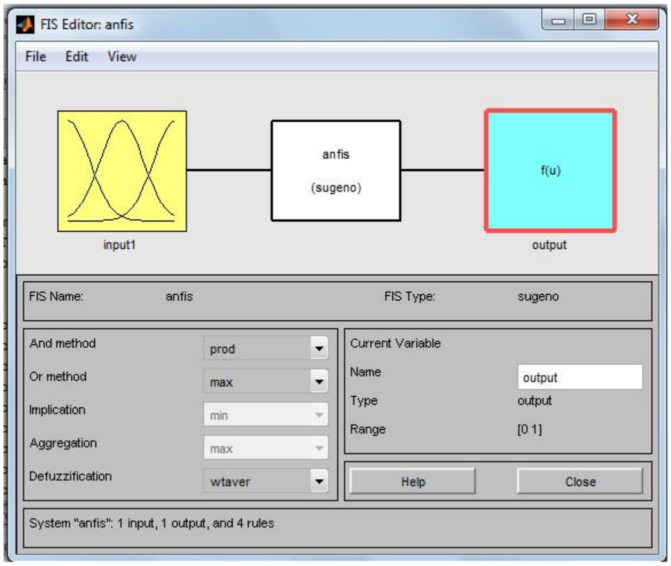

Figure 7 ANFIS editor

Figure 8 is the graph between the input and the degree of membership (lies between 0 and 1).here inmf1 and inmf2 are the INMFLebels. The degree of membership for in1mf1 is varies 1 to 0 to the input range [-2890 4690] and for the in2mf2 degree of membership varies 0 to 1 to the input range [-2890 4690].

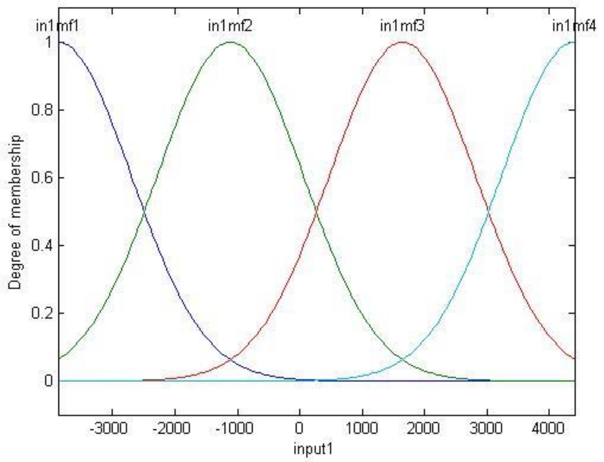

Figure 8 ANFIS Plot of membership function

Fig-9 show the ANFIS rule viewer, where the left part indicates the input in yellow colour and right part indicate the output in blue colour correspond to the input.

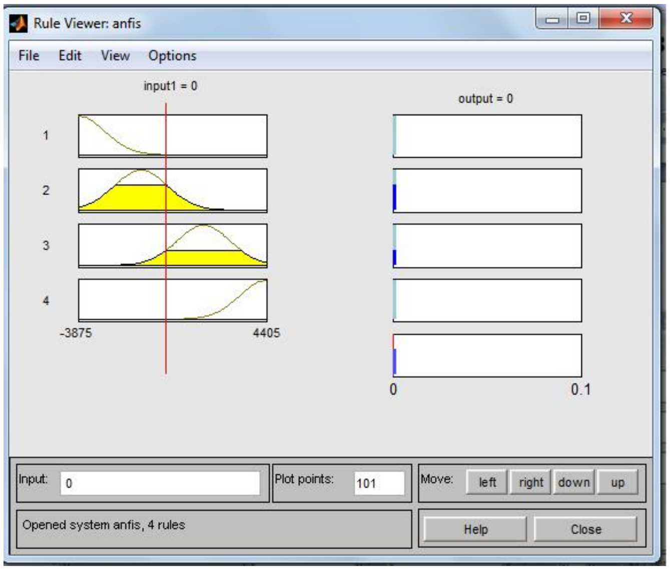

Figure 9 ANFIS Rule Viewer

5 Results:

Result of processing of normal and abnormal ECG signal is shown in tabular form

Name	Signal Number	Status	% Accuracy
Malignant Ventricular ECG	419	confirm	80
	427	confirm	
	428	confirm	
	611	Not confirm	
	612	confirm	
Artial Fibrillation	7879	confirm	100
	7910	confirm	
	8215	confirm	
	8219	confirm	
	8378	confirm	

6 Conclusion:

The conclusion resulting from this work is that, by using the MATLAB [15] based adaptive neuro-fuzzy interface system design and simulation; some better networks can be prepared which have capability to understand all type of arrhythmia ECG database. This type of network can be very reliable as

MATLAB provides a better and understandable set of tools so that the network parameters can be adjusted and precisely easily, such type of network can handle a large amount of database and can work easily with unseen database. The accuracy obtained by such network is comparatively good. The above ANFIS method for analysis of ECG signal gives 90% average percentage of correct classification without using the any feature extraction techniques. Proposed ANFIS model used for detection Artial Fabrillation and Malignant Ventricular ECG arrhythmia is proving to be a very reliable precise method of analyzing both arrhythmia ECG signals.

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