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A Novel Neural Network based Classification for ECG Signals

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Abstract— Cardiac Arrhythmia represents heart abnormalities. This problem is faced by people, irrespective of age. Even the physicians feel difficulty in diagnosing the abnormal behavior of heart accurately. Accurate detection of cardiac abnormalities helps to provide right treatment. Classification plays an important role in predicting abnormal behaviors of heart and it helps the physician to treat the patients who are having cardiac arrhythmia. Extracted features from ECG (Electrocardiogram) signals are used for classification. It is possible to extract multiple features from ECG signal regardless of the features used for classification. Classification performed using all the extracted features leads to misclassification of abnormalities. So feature selection is an important concept in classifying the normal and abnormal behavior of heart. MIT BIH Arrhythmia dataset is used in our proposed work where the classification is done in MATLAB using Fitting Neural Network.

Keywords-*ECG Signal; Classification; Neural Network; Fitting NN; Evaluation Metrics.*

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I. INTRODUCTION

The electrocardiogram (ECG) is the only device which is used for recording the electrical activity of human heart. Electrical activity of heart is generated by the depolarization (contraction) and repolarization (relaxation) of atria and ventricles. Now-a-days many people are suffering from various heart problems which may eventually leads to a life threatening abnormal behavior of heart. All these heart problems must be diagnosed and treated by the doctor as earlier as possible. ECG's are usually recorded on a device and printed on a paper which is used by the doctor for classifying the cardiac arrhythmia to provide accurate treatment for the patients. The recorded ECG signals may contain noises such as Baseline wandering, Power line interference, Muscle noise, Instability of electrode-skin contact, Instrumentation and electrosurgical noise. These noise data leads to misclassification of cardiac arrhythmias. So, ECG signals must be preprocessed before classification and then the features are extracted from them for classification.

II. LITERATURE SURVEY

Comparison the Various Clustering and Classification Algorithms of WEKA Tools was proposed by Sonam Narwal and Mr. Kamaldeep Mintwal [1] where they presented the comparative study of various clustering and classification techniques using Waikato Environment for Knowledge Analysis. The algorithm or methods tested were DBSCAN, EM & K-MEANS clustering algorithms. J48, ID3 and BAYES NETWORK CLASSIFIER classification algorithms.

Choosing the Right Data Mining Technique: Classification of Methods and Intelligent Recommendation was proposed by Karina Gibert, Miquel Sànchez-Marre and Víctor Codina [2] where they presented a classification of most common data mining methods in a conceptual map which made easier selection process. Also an intelligent data mining assistant was presented.

Classification of Ecg Arrhythmias using Discrete Wavelet Transform and Neural Networks was proposed by Maedeh Kiani Sarkaleh and Asadollah Shahbahrami [3] where they presented an expert system for ElectroCardioGram (ECG) arrhythmia classification. Discrete wavelet transform was used for processing ECG signals and the Multi-Layer Perceptron (MLP) neural network were chosen for classification task.

Using Classification to Evaluate the Output of Confidence-Based Association Rule Mining was proposed by Mutter_et_al [4] where they presented the use of classification performance as a metric for evaluating their output. Experiments were conducted on 12 UCI datasets showing that the quality of small rule sets generated by Apriori can be improved by using the predictive Apriori algorithm. They also presented that CBA, the standard method for classification using association rules, is generally inferior to standard rule learners concerning both running time and size of rule sets. Automatic Classification of Heartbeats Using Wavelet Neural Network was proposed by Benali et al [5] where they proposed a method for ECG heartbeat pattern recognition using wavelet neural network (WNN). An algorithm for QRS detection was first implemented, and then a WNN Classifier was developed.

ANN Based GUI for ECG Classification and Normality Detection was proposed by Priya Sharma [6] where they focused on computer based automated system in the analysis of the ECG signals in which the images were fed into the system and the software extracts the ECG signal from the image and feed it to the ANN (Artificial Neural Network) classifier. ECG Classification with the Help of Neural Network was proposed by Gaurav Kumar Jaiswal and Ranbir Paul [7] where they presented best neural network structure for abnormality classification by finding the normal region for classification of cardiac arrhythmia.

Automatic Classification of ECG signal for Identifying Arrhythmia was proposed by V. Rathikarani and P. Dhanalakshmi [8] where they proposed an efficient technique to automatically classify the ECG signals into normal and arrhythmia affected (abnormal) category. For these categories features such as Linear Predictive coefficients (LPC), Linear

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predictive cepstral coefficients (LPCC) and Mel-Frequency Cepstral Co-efficient (MFCC) were extracted to exemplify the ECG signal. SVM was the model engaged to capture the distribution of the feature vectors for classification and the performance was calculated.

Classification of Arrhythmic ECG Data Using Machine Learning Techniques was proposed by Abhinav Vishwa, Mohit K. Lal, Sharad Dixit, Dr. Pritish Vardwaj [9] where they proposed an automatic ANN based classification system in producing high confident arrhythmia classification results to be applicable in diagnostic decision support systems. Neural network model with back propagation algorithm was used to classify arrhythmia cases into normal and abnormal classes. Identification of Cardiac Arrhythmia with respect to ECG Signal by Neural Networks and Genetic Programming was proposed by Nalla.Srinivas, A.Vinay Babu, M.D.Rajak, Syed Musthak Ahmed [10] where they performed classification by using ANN and they results were analyzed by Genetic Algorithm.

III. METHODS AND MATERIALS

The following Fig. 1 represents the systematic flow of classification.

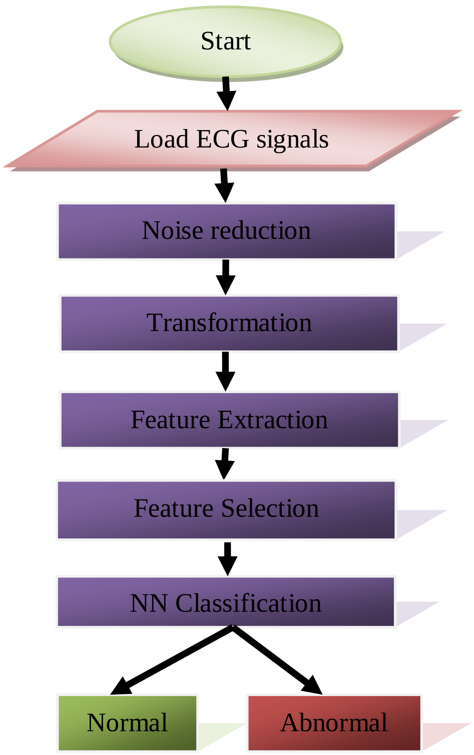

Fig 1. Systematic flow of ECG signals for classification.

A. ECG INTRODUCTION

Electrocardiography is used to interpret the electrical activity of the human heart. ECG signals are non stationary waves which vary from person to person based on their heart conditions. Normal ECG cycle comprises of P-wave, QRS complex, T-wave which looks like Fig 2.

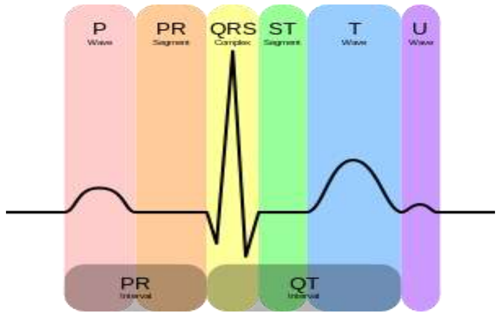

Fig 2. Normal ECG cycle [GOOGLE SOURCE].

P Wave – Represents the Atrial Depolarization (contraction) of heart. **PR Segment** – Indicative of the delay in the AV node. **PR Interval** – Refers to all electrical activity in the heart before the impulse reaches the ventricles. **QRS Complex** – Signifies ventricular depolarization of heart in which **Q Wave** – Represents the First negative deflection after the P wave but before the R wave, **R Wave** –Represents the First positive deflection following the P wave, S **Wave** – Represents the First negative deflection after the R wave. **T Wave** – Indicates ventricular re-polarization's (relaxation) of heart. **ST Segment** – atrial cells are relaxed and the ventricles are contracted so electrical activity is not visible. **QT Interval** – represents the duration from the depolarization to the repolarization of the ventricles [11].

B. DATASET

MIT BIH arrhythmia dataset is used for extracting the features of ECG signal. It contains 4000 long-term Holter recordings that were obtained by the Beth Israel Hospital Arrhythmia Laboratory. It contains 48 inpatient records [12].

C. FEATURE EXTRACTION AND SELECTION

Features are extracted by performing FWHT transformation on MIT BIH arrhythmia dataset. Features like average, maximum, variance, standard deviation, kurtosis were extracted from the determined peak values [13]. In our research work, we have used two features i.e. Average and Maximum to determine the accuracy of classification.

D. CLASSIFICATION TECHNIQUES

Generally classification is a two step process. First step is the supervised learning which is the process of assigning predefined class labels for training data and the second step is classification accuracy evaluation. Due to all these factors classification is a form of "***learn by example***". Classification is done only after Data Cleaning – removing noise and missing data, Relevance analysis – many redundant attributes must be removed by correlation analysis and Data transformation and reduction. There are many classification algorithms in which neural network performs best. Neural network is an interconnection of input and output neurons with associated weights in each connection. It has the ability to highly tolerate the noisy data. NN are inherently parallel which speed up the computation process. Back propagation learns by iteratively processing the training instances in which the weights adjustments are made in the backward direction to minimize the error. In this research work we chose neural network fit function for classification in MATLAB. The selected features are then applied for chosen classification technique in

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MATLAB. Transfer functions are tansig and linear. 'trainlm' is used as Back propagation network training function. 'learngdm' is used as Back propagation weight/bias learning function [14].

E. CLASSIFIER EVALUATION METRICS

Fitting neural network Classifier is applied on this MIT BIH Arrhythmia dataset. Their results are analyzed and used to determine the accuracy of classifier. There are various evaluation metrics which determines the accuracy of classifier. Accuracy is measured on test sets which denotes the percentage of test set tuples that were correctly classified by the classifier. **Error rate** or **Misclassification rate** of a classifier C can be determined as **1-Acc(C)**, where Acc(C) is the accuracy of classifier C. Confusion matrix which is seen in Fig 3 is a tool for analyzing how well classifier can recognize tuples of different classes [15].

		PREDICTED CLASS	
		C1	**C2**
ACTUAL CLASS	**C1**	**TP**	**TN**
	C2	**FP**	**FN**

Fig 3. Confusion Matrix

Various classifier evaluation metrics are listed below [16]:

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

$$F - \text{Measure} = \frac{2.\text{Precision}.\text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

where,

- TP – true positive, represents that the positive tuples are correctly classified.
- TN – true negative, represents that the negative tuples are correctly classified.
- FP – false positive, represents that the negative tuples are incorrectly classified.
- FN – false negative, represents that the positive tuples are incorrectly classified.
- Precision – represents how many selected tuples are classified correctly.
- Recall – represents how many relevant tuples are selected.
- F-Measure – represents a measure that combines precision and recall is the harmonic mean of precision and recall.

IV. RESULTS AND DISCUSSIONS

This research work proposed a neural network technique, Fitting Neural Network for giving best accuracy of ECG signal classification. Input ECG signals are preprocessed to remove noisy data and transformed to extract the features. Further, using the features selected, Fitting Neural Network classification is implemented which obtained the following result.

Correctly Classified Instances : 46
Incorrectly Classified Instances : 2

CLASS	PRECISION	RECALL	F-MEASURE
Normal	0.965517	0.965517	0.965517
Abnormal	0.947368	0.947368	0.947368

Sensitivity : 0.965517%
Specificity : 0.947368%
Accuracy : 0.958333%

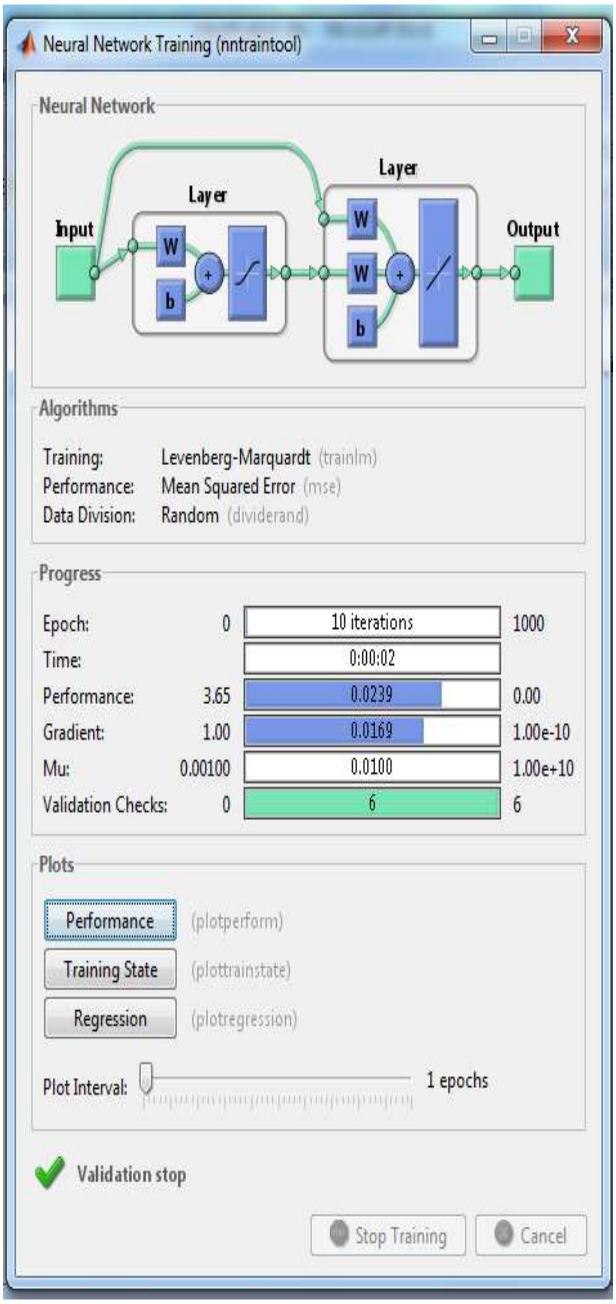

Fig 3. Neural Network Tool.

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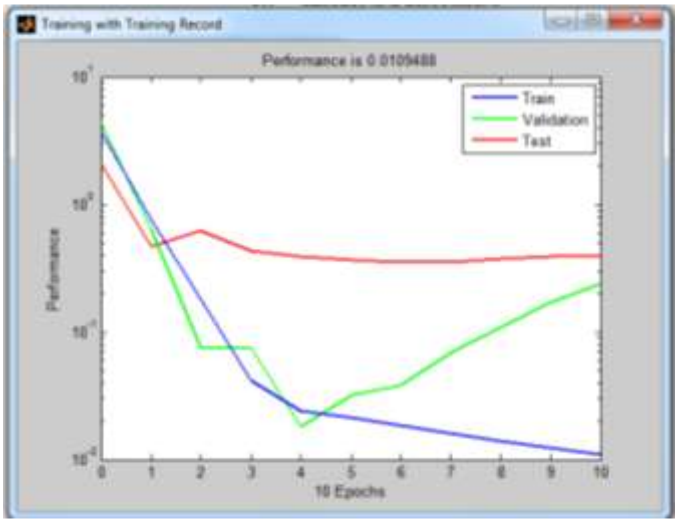

Fig 4. Training record chart.

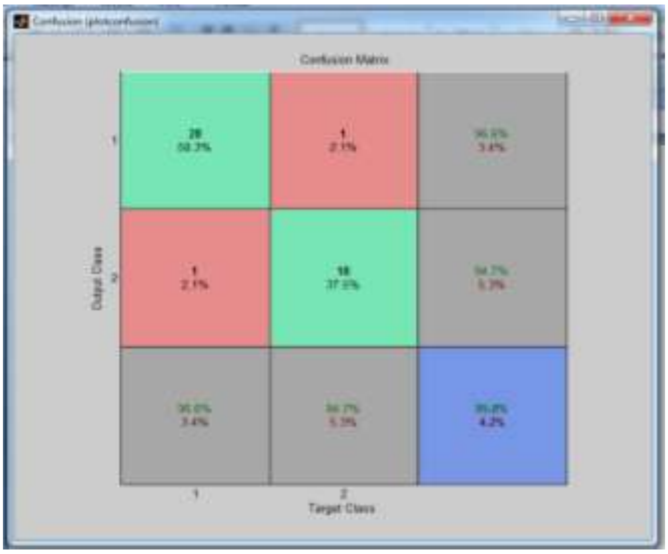

Fig 5. Confusion Matrix.

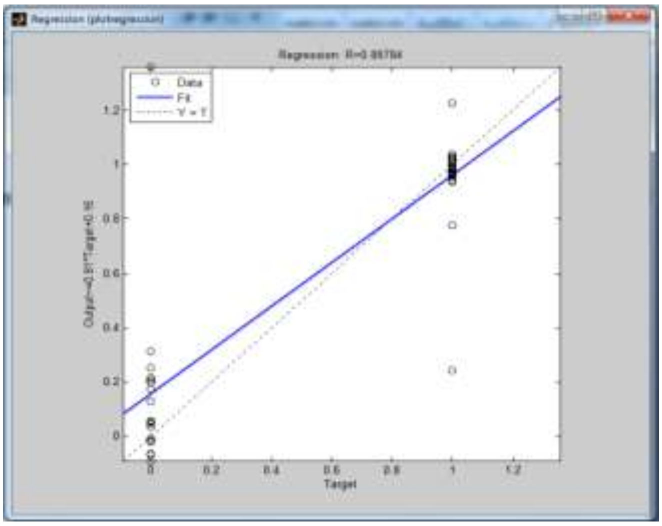

Fig 6. Regression Chart.

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