INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 2)
Available online at: www.ijariit.com

Arrhythmia classification using ECG Signal based on BFO with LMA Classifier

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ABSTRACT

Electrocardiogram (ECG), a non-invasive technique is used as a primary diagnostic tool for cardiovascular diseases. ECG provides valuable information about the functional aspects of the heart and cardiovascular system. The detection of cardiac arrhythmias in the ECG signal consists of detection of QRS complex in ECG signal; feature extraction from detected QRS complexes; classification of beats using extracted feature set from QRS complexes. Earlier methods have been developed by authors to predict heart disease on the basis of ECG but as each method has its own advantage as well disadvantage. Hence, in this thesis, the best training method i.e. Levenberg Marquardt algorithm has been utilized for classification on the basis of validation checks or epochs with an optimization technique. The purpose of this research work is to classify the disease dataset using Bacterial Foraging Optimization (BFO) Algorithm and trained by Levenberg Marquardt algorithm on the basis of the features extracted and also to test the image on the basis of the features at the database and the features extracted of the waveform, to be tested. The advantage of the proposed method is to minimize the error rate of the classification which occurs due to an insignificant count of R-peaks. The database from physionet.org has been used for performance analysis. Several experiments are performed on the test dataset and it is observed that Levenberg-Marquardt Algorithm classifies ECG beats better as compared to Back Propagation Neural Network (BPNN). FAR, FRR and accuracy parameters are used for detecting the ECG disease. The simulation process is undergone by using MATLAB simulation tool.

Keywords: *ECG signals, Bacterial Foraging Optimization (BFO), Levenberg-Marquardt Algorithm (LMA) and MATLAB.*

1. INTRODUCTION

The aim of ECG signals processing is to provide the perfection of accuracy, reproducibility and the removal of information not available from the signal. In many situations, the ECG is recorded during exhausting conditions such that the signal is despoiled by different types of noises; sometimes originate from another physiological body procedure [1]. So, reduction of noise shows another significant purpose of ECG signal processing; in fact, the waveforms of attention are sometimes so greatly masked by the noise that their occurrence can only be exposed once suitable signal processing has first been functional [2].

All types of ECG analysis, whether it takes resting ECG analysis, stress testing, ambulatory monitor or concentrated care monitoring are the essential set of algorithms that state the signal with respect to dissimilar types of noise and artefacts [3]. Although these algorithms are regularly implemented to operate in sequential order as produced by the QRS detector and are sometimes incorporated into the other algorithms to improve the performance [4].

The electrocardiogram (ECG) is a physiological signal as shown in Figure below that represents the mechanical heart contraction and relaxation [5]. If P, QRS is upward, T is Downward, RR0 is Normal, RR1 is Normal then the type is Normal ECG Signal [6].

- P wave: contraction of the atria.
- QRS: equivalent to a contraction the ventricles.
- T wave: is the relaxation of ventricles.

The ECG can be divided into different time segments and intervals related to the phases of myocardium stimulation as shown in Figure 1.

- PR Interval: It represents the interval from the beginning of artial depolarization to beginning ventricular depolarization.
- PR Segment: It starts from the end of P wave and ends at the start of QRS complex.
- QT Interval: It represents the time from depolarization to the re-polarization of ventricles.
- ST Segment: It starts from the end of QRS complex to the beginning of T wave.
- RR Interval: It measures the time between two successive R peaks.

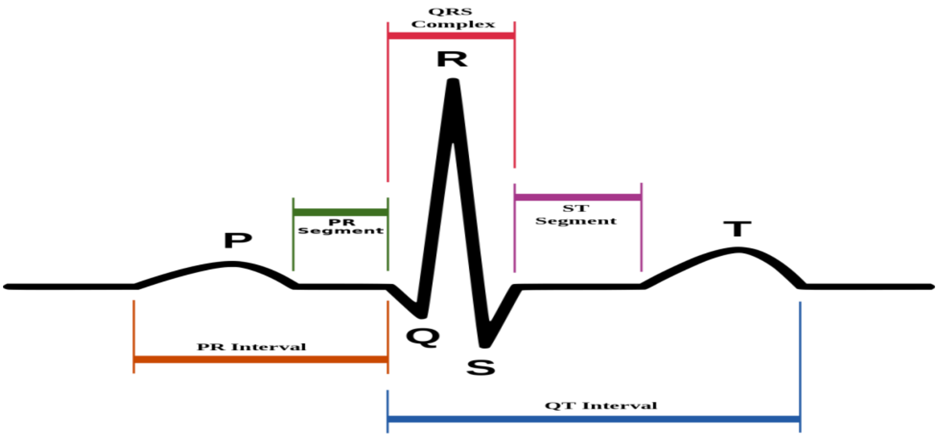

Figure 1: ECG wave form

PQRST waveform analysis has proved to be a valuable approach for the identification of multiple cardiac diseases [7].ECG signal is the resemblance of the combination of bell curve such as P, Q, R, S along with T waves; it falls toward both sites that are one of the features of Gaussian wave [8].

2. MATERIALS AND METHODS

Mainly two algorithms are used in the proposed work one is for optimization and other is for classification [11]. For optimization, BFO (Bacterial Foraging optimization) algorithm is used and for classification, LMA (Levenberg-Marquardt Algorithm) is used.

BFO algorithm motivated by the foraging and Chemo tactic behaviors of bacteria, especially the Escherichia coli (E. coli). Locomotion can be achieved during the process of real bacteria forging through the tensile flagella set. Flagella help an E.coli bacterium to fall or swim, that are two essential operations performed by a bacterium at the instance of foraging [12]. When they revolve the flagella in the clockwise direction, every flagellum pulls over the cell. That results in the moving of flagella separately and lastly, the bacterium tumbles with a smaller amount of tumbling while in a damaging place it tumbles repeatedly to find a nutrient gradient. Stirring the flagella in the counter clockwise direction helps the bacterium to swim at a very speedy rate [13].

3. RELATED WORK

Recognition of ECG signal suffers from various problems, after the analysis on several papers, it is being concluded that there is a big problem of the accurate feature set. So, optimization and training of data are very important before classification, which is mainly done by using (BFO) and Levenberg neural network. This research has tried to solve the problem of finding the exact feature of ECG signal and optimization of the feature set. In the end, FAR, FRR and Accuracy result evaluation is done in MATLAB.

Zheng *et al.* (2013) discussed a cardiovascular disease that has become the leading cause of human deaths. In order to fighting this disease, a lot of professionals are using mobile electrocardiogram remote monitoring system.

Mortaheb *et al.* (2013) proposed the multi-step method with regard to automatic segmentation from the tooth within dentist CT images. The result evaluation implies that the exactness involving proposed technique is usually over 97.1%. Additionally, they contrast the particular proposed process with a threshold, watershed approaches.

Gaikwad *et al.* (2014) described that ECG as the major tool used by the physician for identifying and for an understanding of Heart condition. The ECG should be free from noise and of good excellence for the correct diagnosis.

Srinivasulu *et al.* (2014) proposed multi-swarm optimization (MSO) method to identify automatically the cut of frequency of multichannel ECG signal. ECG waveforms are affected by noise and artefacts, thus, it is necessary to remove the noise so that the doctor can detect the correct disease.

Vishnu Gopeka *et al.* (2014) have presented the extremely large scale integration based electrocardiogram QRS detector for wearable devices, in dead body sensor networks. The authors have used Multistage Mathematical Morphology technique used to restrain background noise and baseline wandering from original ECG signal.

Odinaka *et al.* (2015) examined the voltage generated from the heart signal using an electrocardiogram (ECG). Information security becomes the key issue when the user tried to link the wireless body sensor network with the healthcare social network by means of mobile facilities.

4. SIMULATION MODEL

In the proposed work, a unique objective function which provides the better results from the previous work can be defined. In the proposed work, *Levenberg–Marquardt algorithm* (LMA) and *Bacterial foraging optimization algorithm* (BFOA) is utilized for faster and accurate detection of diseases from the ECG signal for any heart related-problem. In the end, the performance of the system can be measured using following parameters:

i) False Accept Rate (FAR): FAR is the type of error in the pattern recognition system which is measured by:

$$\mathrm{FAR} = \frac{\text{Total Number of Features} - \text{Total Number of Falsely Accepted Features}}{\text{Total Number of Features}}$$

ii) False rejection rate (FRR): The FRR of the system is the rate of the falsely rejected feature with respect to the total feature. Its formula is given as:

$$\mathrm{FRR} = \frac{\text{Total Number of Features} - \text{Total Number of Falsely Rejected Features}}{\text{Total Number of Features}}$$

iii) Accuracy: Accuracy is a general term used to describe how accurate a system performs. Its formula is given as:

$$\text{Accuracy} = 100 - (\mathrm{FAR} + \mathrm{FRR})$$

The methodology of the process can be understood with the following flow diagram which clearly explains the work in steps:

Step 1: Upload ECG signal dataset for Bradycardia and Tachycardia heart disease.

Step2: Extract feature from the uploaded ECG signal based on the threshold value according to the QRS peaks.

Step3: Develop a code for the BFO optimization algorithm to optimize the features according to the fitness function of BFO algorithm. So set the novel fitness function in the BFO optimization algorithm.

Step 4: Initialize Levenberg Marquardt algorithm for classification purpose using two phases, namely,

- Training phase
- Testing Phase

Step 5: Train uploaded ECG signals according to their feature using Levenberg Marquardt algorithm.

Step 6: Load Test Sample and repeat Step 2 and 3 after that classify the Diseases according to categories which are generated during the training phase

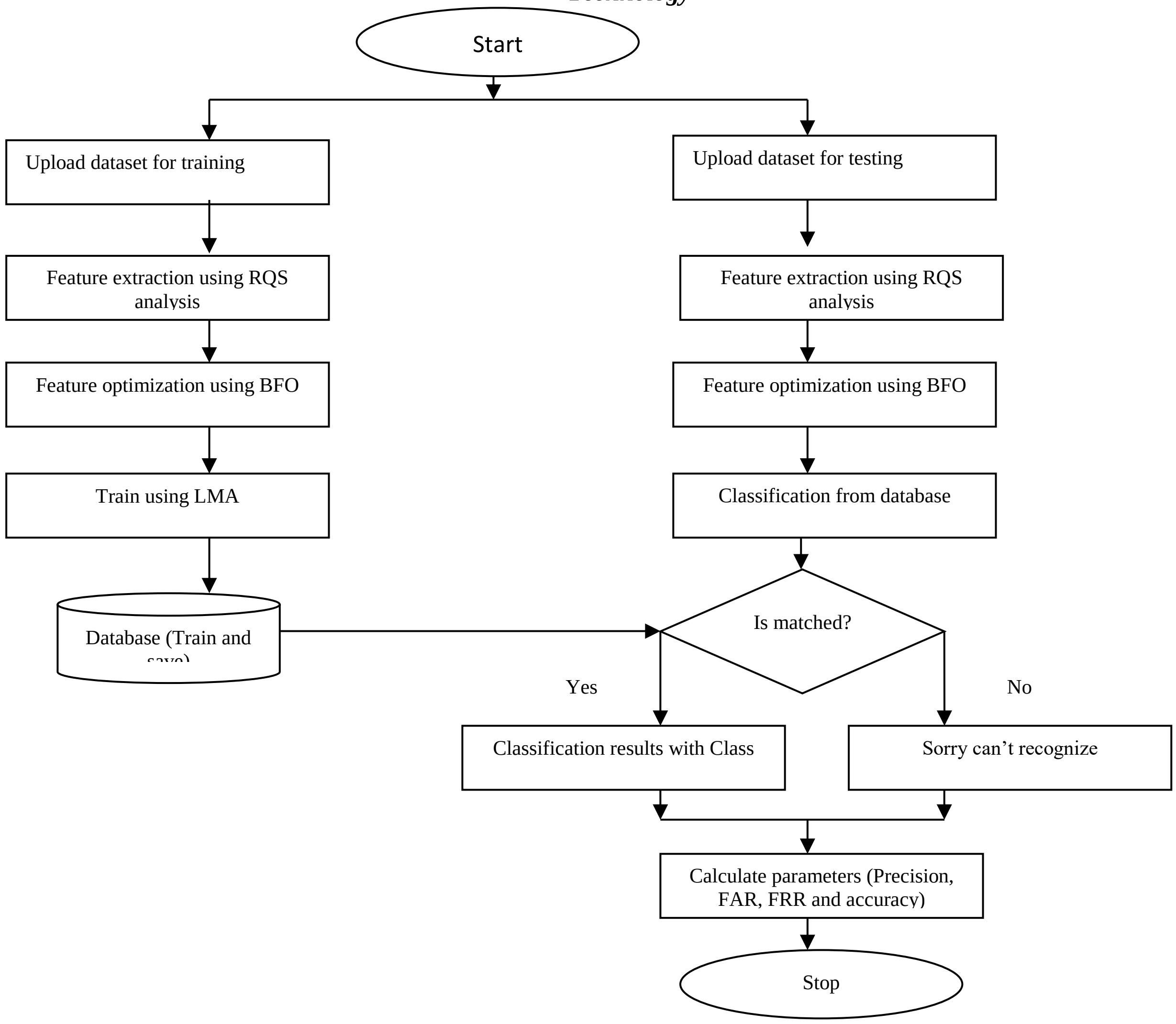

Figure 2: Proposed Work Flowchart

5. SIMULATION RESULTS

This section explains the results obtained after the implementation of the proposed work. In this research work, a system is developed for ECG disease that is Bradycardia and Tachycardia recognition. For optimizing the extracted features BFO is used whereas, for classification LMA is used.

Figure 3: Working Main Window

The figure 3 describing the main window for the proposed work that is the Disease Classification using ECG signal based on BFO with LMA classifier. In this title widow, there are two buttons named as a Start button and Exit button. If we click on start button, simulation window opened and if we click on Exit button, the simulation window closed. In simulation window, the title of the proposed work has been displayed as "Arrhythmia classification using ECG Signal based on BFO with LMA Classifier".

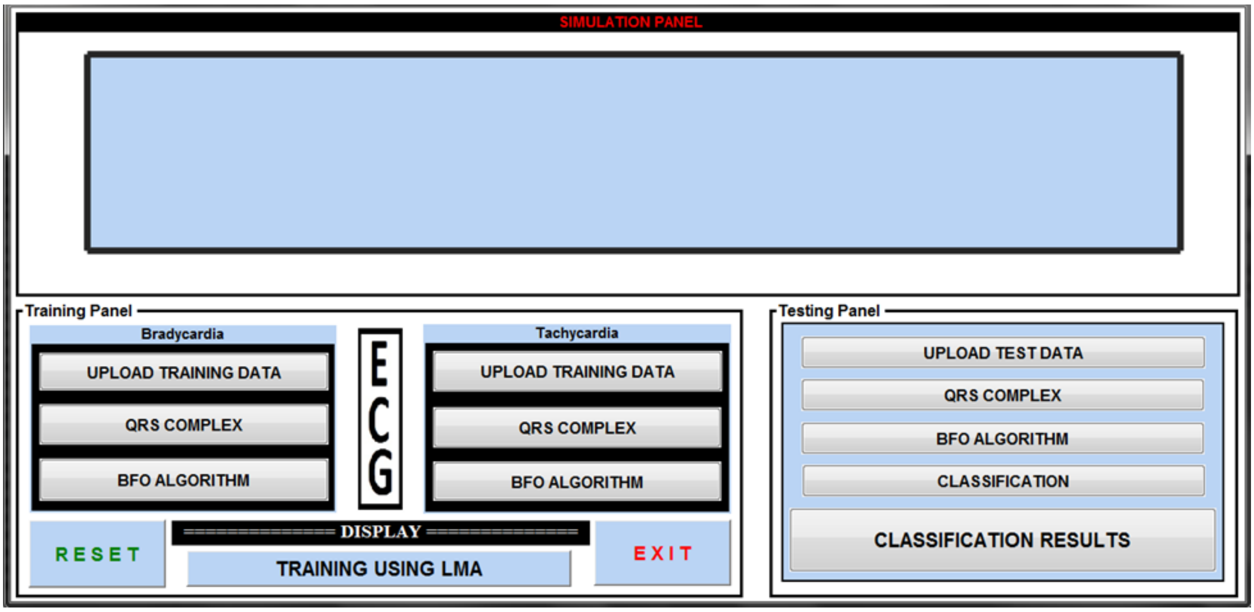

Figure 4: Working figure window

Figure 4 shows the main window of the proposed ECG Disease Detection System. The system is mainly categorized into three steps: Feature Extraction & optimization, training, and testing. In the above figure, there are two panels named as Training and testing panel. Training panel again categorized into two subparts named as Tachycardia and Bradycardia. Every section has three sub-sections namely; upload training data, QRS complex, and BFO algorithm.

5.1 Training Panel

In training panel, the correct class of every phase is known, this is known as supervised training. The output value is obtained from this panel is thus assigned to 1 for the correct class, whereas for other class system assigns 0 values. Thus, by comparing these values it is easy to calculate the error and thus, the weight of the neurons is adjusted accordingly so that one can get the accurate value.

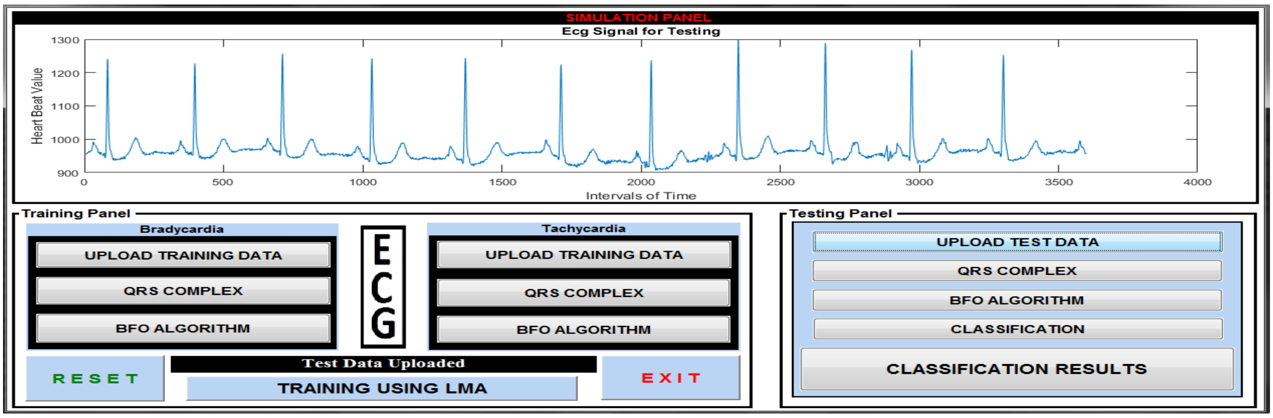

Figure 5: Upload training data

When we click on Upload training data in Bradycardia, Trained data for Bradycardia get uploaded similarly for the tachycardia disease. Here, BFO algorithm is used for optimizing the results and LMA is used for the classification purpose. The artificial neural network is used to give the accurate results by comparing the output with the dataset. If any error occurs then it adjusts the weight of the neuron accordingly, so that, error get reduced and to obtain the desired result.

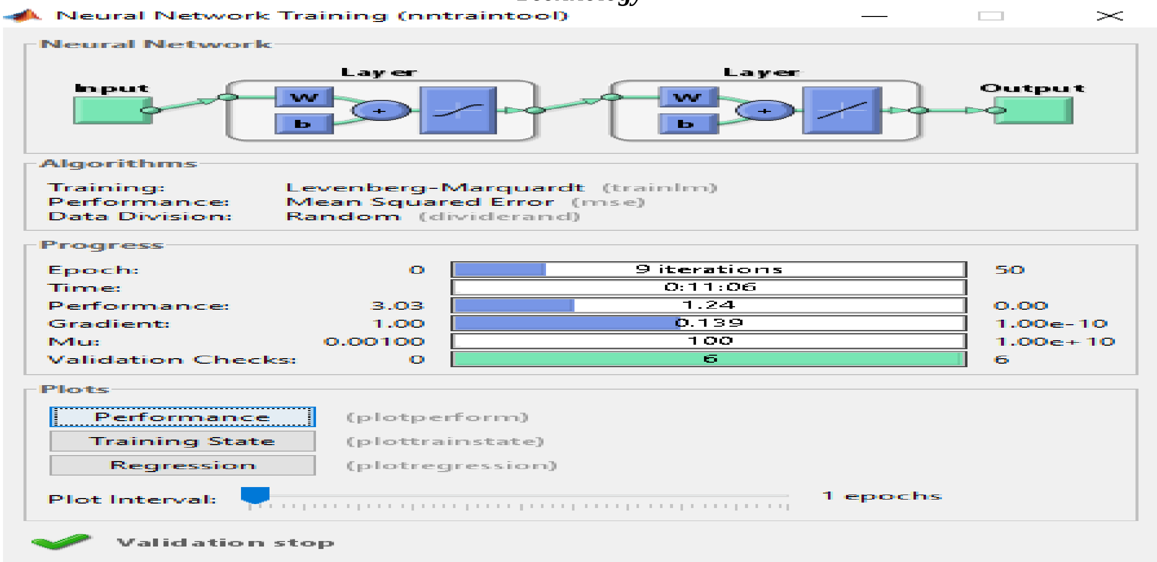

Figure 6: Neural network training state

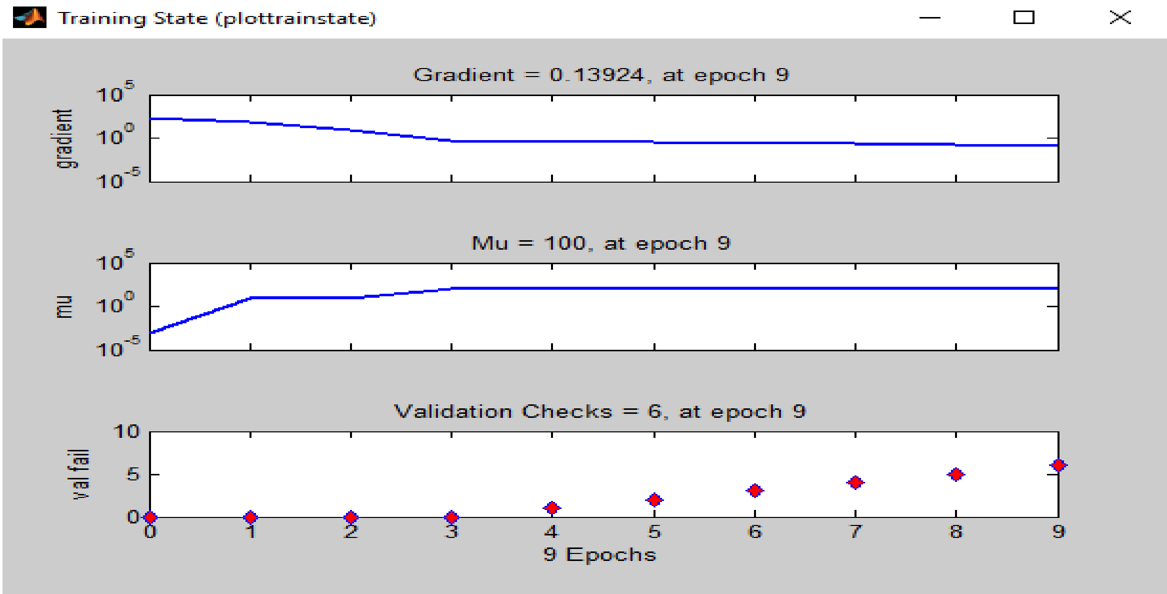

Figure 7: Training set parameters

Figure 7 shows the different types of a parameter which are generated during training of dataset. It is being checked that whether the best gradient value, mutation value, and validation checks are achieved

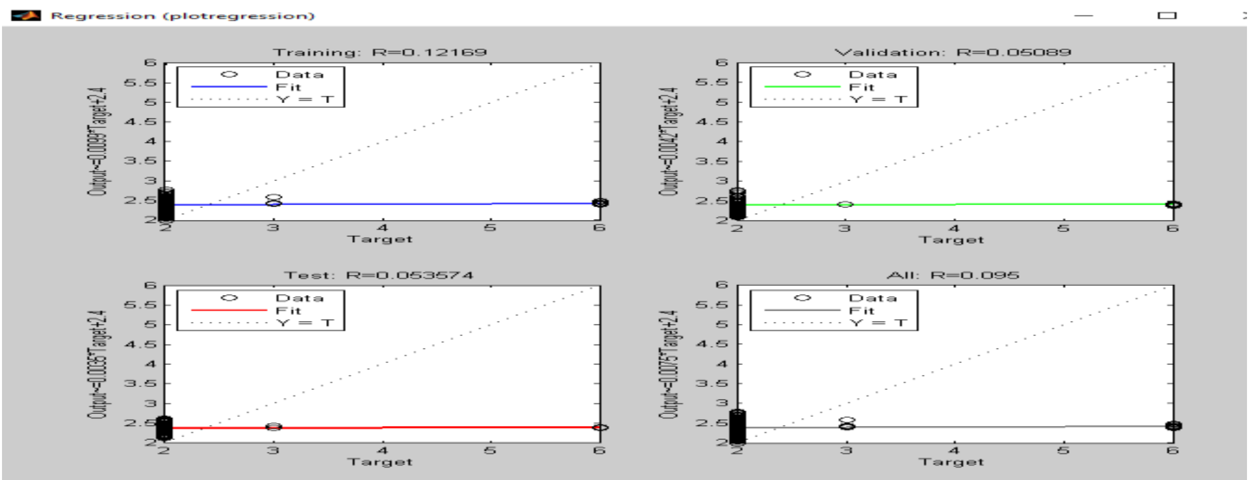

Figure 8: Datasets used for training

Figure 8 shows the description of datasets which are used for the training purpose of the dataset. There is total four graphs, first for training data, second for validation and third for test data that are automatically taken from the training dataset and last for output of training. In the above graph, two lines are present, first is a solid line and second is doted line which represents the accuracy of training. The three plots stand for the training, validation, and testing data. The dashed line in every plot represents the perfect result – outputs = targets. The solid line shows the finest fit linear decay line between outputs and targets. The R-value is a sign of the bond between the outputs and targets. If R = 1, this indicates that there is an exact direct relationship between outputs and targets. If R is close to zero, then there is no direct relationship between outputs and targets.

5.2 Testing panel

The testing panel is shown in the right-hand corner of the working panel. It consists of different working buttons named as: upload test data, QRS complex, BFO algorithm, Classification and classification results.

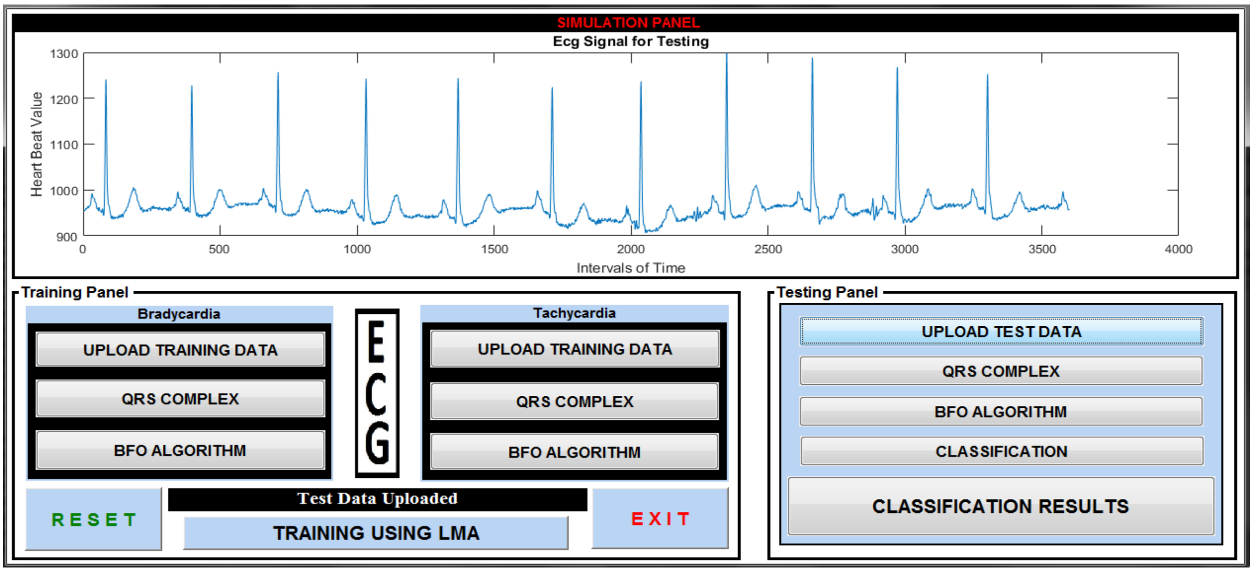

Figure 9: Upload test data

The Figure 9 shows the dataset uploading for ECG signal. The Uploaded ECG signal is shown in the above figure having time is on x-axis and heart beat value of ECG signal is on y-axis. Signal has a maximum time of 4000 and peak value that is amplitude is of 1300 mv maximum. After uploading the ECG signal, signals are now extracted on the basis of their feature.

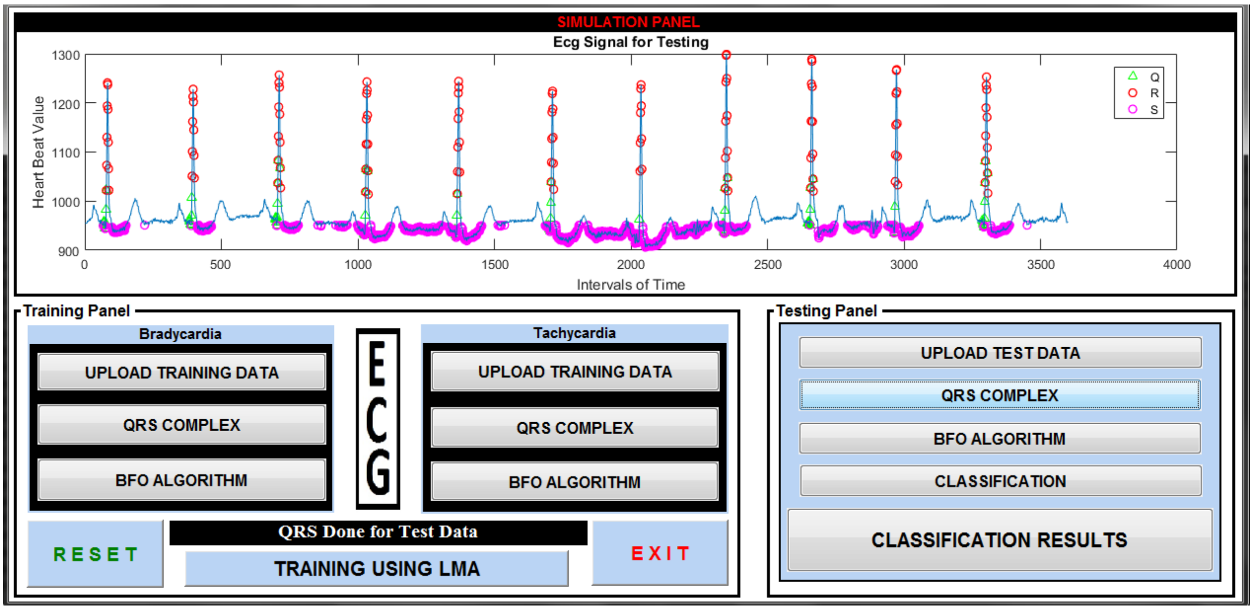

Figure 10: QRS complex of uploaded test data

After uploading the samples for ECG signal, next step is to extract features. When we click on QRS complex, the above waveform gets displayed on the screen. Here, the green circle represents the Q peak of ECG signal, red circle represents the R peak of ECG signal and Megenta circle represent the S peak of the uploaded ECG signal. These signals are finding on the basis of threshold technique.

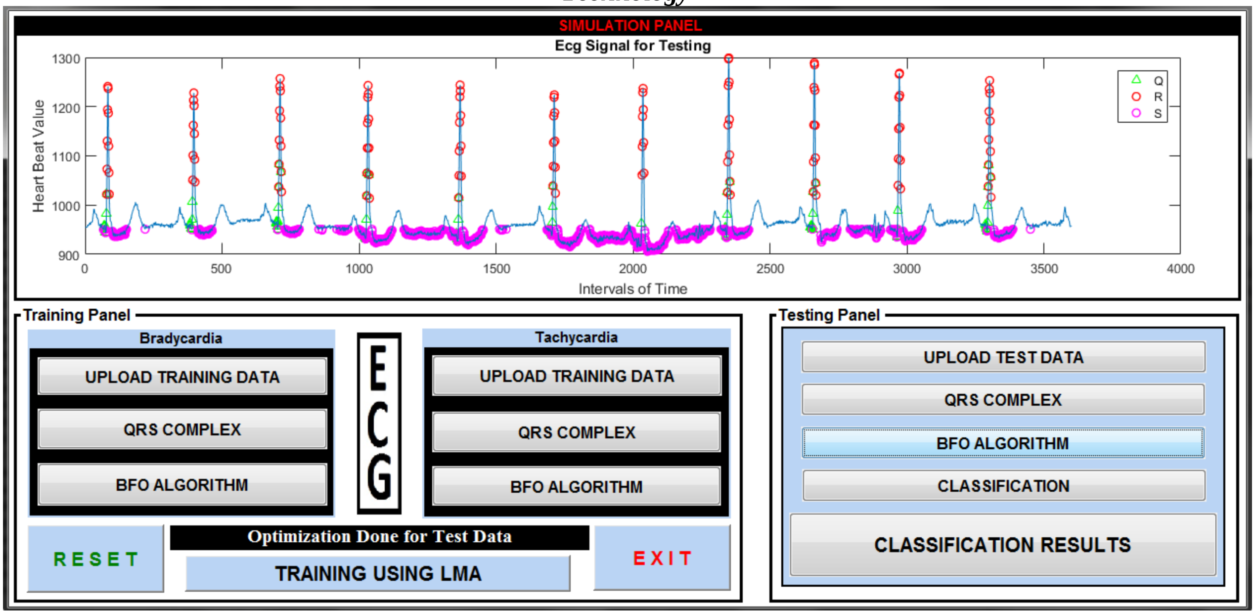

Figure 11: QRS optimization using BFO Algorithm

After extracting the QRS complex from the ECG signal. The extracted features are improved by using optimization algorithm known as BFO (Bacterial foraging optimization algorithm). This is a global optimization algorithm that was inspired by the social foraging behavior of Escherichia coli.

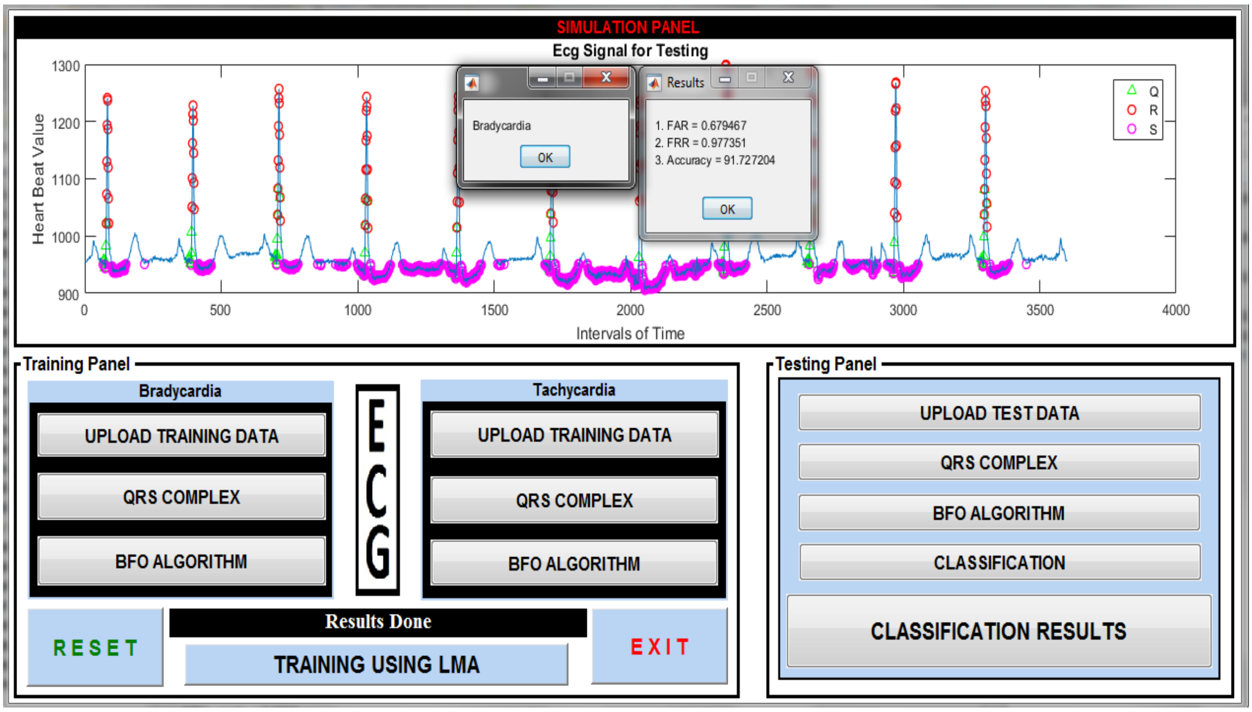

Figure 12: Classification of test data using LMA

In this research work, the cardiac disorder classified into two parts named as (i) Bradacardia (ii) Techacardia. For effective training, it is desirable that the training data set be uniformly spread throughout the class domains. The available data can be used iteratively until the error function is reduced to a minimum.

Table 1: Performance parameters for cardiac disorder

Sr. no	FAR	FRR	Accuracy
1	0.679	0.977	91.72
2	0.634	0.936	93.52
3	0.595	0.837	95.34
4	0.694	0.736	91.95
5	0.635	0.893	92.53
6	0.569	0.976	94.59
7	0.544	0.835	95.46
8	0.529	0.981	94.35
9	0.573	0.935	93.38
10	0.531	0.903	94.85

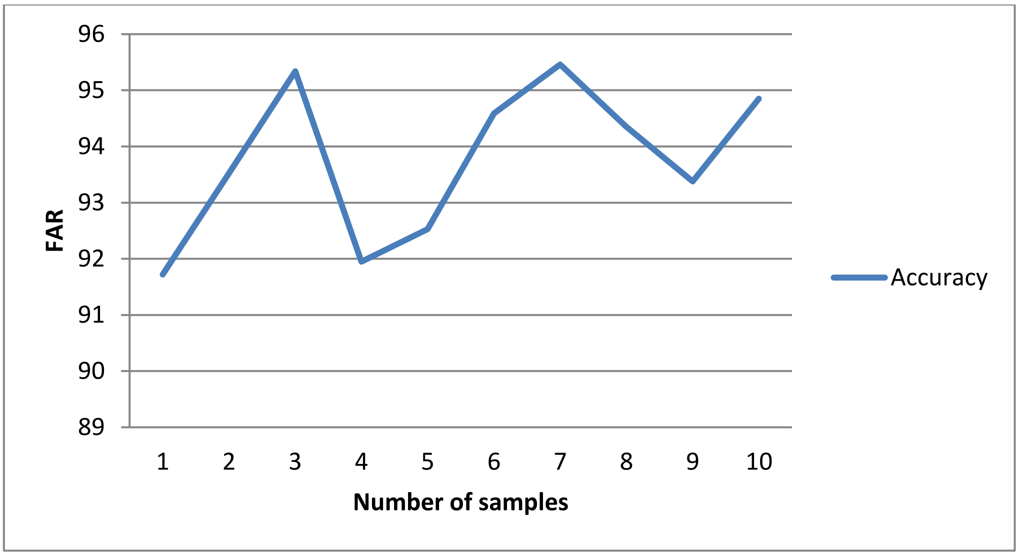

Figure 13: FAR from ECG signal

The graph of FAR for the cardiac disorder is shown above. The graph has a number of the sample along the x-axis that has been taken for experiment and along y-axis, it displays the FAR value of the proposed work. The observed average value of FAR is 0.59.

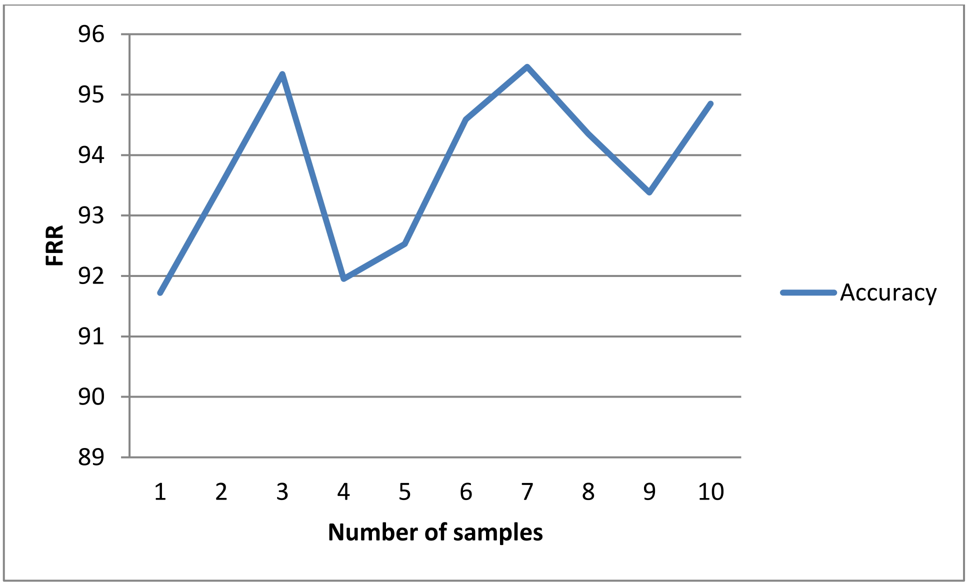

Figure 14: FRR of ECG signal

The graph of FRR for Cardiac disorder is shown above. From the graph, it is concluded that along x-axis there is a number of samples and along y-axis, it displays FRR value of the proposed work. The average value of the proposed work is 0.90.

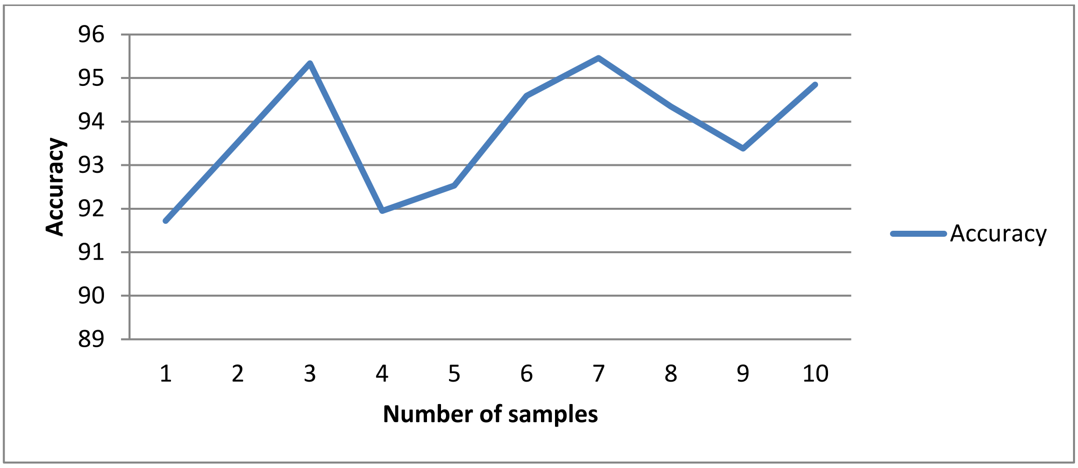

Figure 15: Accuracy of ECG signal

The graph obtained for accuracy has been displayed above. The graph has a number of the sample along x-axis and accuracy value along the y-axis. The average value of accuracy obtained for the proposed work is 93.76.

6. CONCLUSION

An ECG signal is a graphical representation of the cardiac movement for computing the cardiac diseases and to ensure the abnormalities in the heart. The objective of this research work is to categorize the disease dataset using BFO algorithm and to train the Neural Network on the source of the features extracted and moreover, to test the image on the origin of the features at the database and the features extracted of the image to be tested. This research is based on studying the implemented approaches in the ECG diseases and to propose a novel technique/algorithm for classification of two cardiac disorders named as Bradycardia, and Tachycardia dependent on Levenberg Marquardt algorithm and the BFO algorithm. Clinical databases have accumulated large quantities of information regarding patients and their medical situation. Heart Disease is the disease that mainly affects the heart. Most of the losses are due to heart diseases. This dissertation presents the ECG Disease Detection System based on BFO, and Levenberg Marquardt algorithm (LMA), in which detection is based on three parameters, namely, accuracy, FAR and FRR. Simulation results have shown that the obtained value of FAR, FRR and accuracy are in favour of the proposed tested waveform that is 0.59 for FAR, 0.90 for FRR and 93.76 % for accuracy.

Future scope lies in the use of former classifiers like SVM with the aim of having multidimensional data and making use of feature reduction algorithms, so that accuracy rate can be enhanced. SVMs bring a unique solution since the optimality problem is rounded. This is an advantage to Levenberg Marquardt algorithm (LMA), which has several solutions related to local minima and for this reason may not be tough over different samples. For optimization algorithms like Artificial bee colony (ABC) and Particle swarm optimization (PSO) can be used.

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