

Cardiac Analysis and Classification of ECG Signal using GA and NN

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ABSTRACT

Electrocardiogram represents electrical activity of the compassion. Sinus tachycardia and Sinus Bradycardia are among the most common ECG abnormality. Millions of ECGs are in use for the diagnosis of various lesions of patients, where ECG can give a lot of information regarding the abnormality in the concerned patient; ECGs are analyzed by the physicians and interpreted depending upon their knowledge. The understanding may vary by physician to medical doctor. Hence, this labor is all about the mechanization and consistency in the analysis of the ECG signals so that they must be diagnosed and interpreted accurately irrespective of the physician. This would help to create an early action intended for the problems and many lives might be saved. Many works have been done previously but this work presents Electrocardiogram (ECG) classification to diagnose patient's condition. For classification of such Difficult to Diagnose Signals, P-Wave, PR-Interval, QRS Interval, ST Interval, T- Wave etc, analysis of each Input pulse used to train the neural network and features are obtained using Genetic Algorithm. Output of the neural network gives weight factors of each signal to create a data set. Electrocardiogram (ECG) PQRSTU-waveforms time intervals and weight factors and prediction of particular disease infection or state of a patient condition saved in database. A software program is written in MATLAB 7.10. Corresponding output-datasets indicates related disease and predict the causes. The results show a considerable improvement in conditions of FRR, FAR and accuracy of image retrieval.

Keywords

ECG Signal, Neural Network, Genetic Algorithm, T-Cardia, B-Cardia.

1. INTRODUCTION

Noise detection in the ECG signal is the crucial issue in the medical field [1]. For accurate measurement of ECG signal noise reduction is very important [2]. The main aim of

ECG enhancement technique is to reduce the noise and separate the ECG signals so that accurate results can be obtained. The application of ECG signal in medical field is to recognize the ECG signal and then classify the disease according to ECG output [3, 4]. The structure of ECG signal consists of P, QRS complex and T waves [5]. If $0 \in (P, Q, R, S, T)$ Then each component can be represented as below where Q is height of curve:

$$P \text{ wave: } Q_a r - \left(\frac{y - \tau_p}{\sqrt{2} \tau_p} \right)^2 \quad (1)$$

$$Q \text{ wave: } Q_{a1} r - \left(\frac{y - \tau_{p1}}{\sqrt{2} \tau_{p1}} \right)^2 + Q_{a2} r - \left(\frac{y - \tau_{p2}}{\sqrt{2} \tau_{p2}} \right)^2 \quad (2)$$

$$R \text{ wave: } Q_T \frac{de}{dt} \left(\frac{y - \tau_p}{\sqrt{2} \tau_p} \right)^2 \quad (3)$$

$$S \text{ wave: } -Q_d e^{-\left(\frac{y - \tau_p}{\sqrt{2} \tau_p} \right)^2} \quad (4)$$

$$T \text{ wave: } Q_y e^{-\left(\frac{y - \tau_p}{\sqrt{2} \tau_p} \right)^2} \quad (5)$$

Detection of QRS is very important w.r.t other waves. But it is very difficult task because of presence of various noises. The noises which may corrupt original ECG signal are:

1.1 Noise due to muscle contraction (Electromyography interference)

The power spectrum of this noise is given by

$$\bar{V}_n^2 = 4kTR \quad (6)$$

Where k is the Boltzmann's constant, T is the temperature, and R is the resistance

1.2 Line Interference

The manifestation of power line noise can be modeled by:

$$n_{60Hz}(t) = A \sin(2\pi \cdot 60 + \Omega) \quad (7)$$

That is why noise removal in QR signal is must. ECG also used in heart disease classification that is why ECG signal must be noise free [6, 7]. The ECG morphology used for heart detection [8]. The ECG, over a solitary cardiovascular cycle, has a trademark morphology containing a P wave, a QRS complex and a T wave. The typical ECG setups are made out of waves, edifices, sections and interims recorded as voltage (on a vertical pivot) against time (on a flat hub) [9, 10]. A solitary waveform starts and finishes at the gauge. At the point when the waveform proceeds past the benchmark, it changes into another waveform [11]. Two or more waveforms together are known as a complex. A level, straight, or isoelectric line is known as a fragment. A waveform, or perplexing, associated with a section is called an interim. All ECG tracings over the pattern are portrayed as positive redirections. Therefore, ECG signal must be clearly shown and needs to be noise free [12]. The development of exact and fast method intended for regular ECG feature removal that is of chief significance, mostly used for the assessment of long recordings. ECG gets ruined because of a variety of the artifact [13].

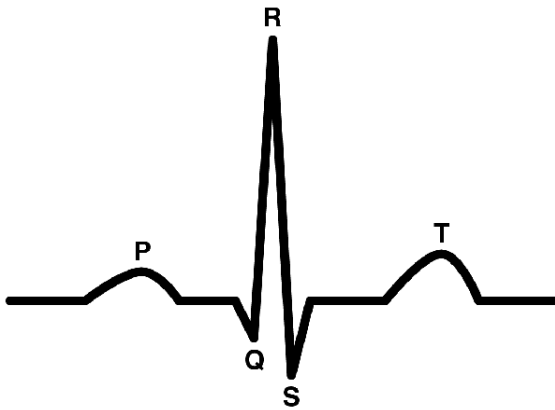


Fig 1: ECG Waveform

In proposed work two diseases like B-Cardia and T-Cardia will be classified using combination of neural network and genetic algorithm. Genetic algorithm will work as feature reduction technique and neural network will work as disease classification technique. The rest of the paper is organized as:

2. GENETIC ALGORITHM

Harik analyzed the growth and decay of a particular gene in the population as one dimensional random walk. As the GA progresses, genes fight with their competitors and their number in the population can go up or down depending on whether the GA makes good or bad decisions. These decisions are made implicitly by the GA when selection takes place. The next section explores the effects of this decision making [19].

2.1 Selection

Proportionate reproduction describes a group of selection schemes that choose individuals according to their objective function values f .

Pseudo Code

```

for all the members of population do
    sum += fitness of this individual
end for
for all members of population do
    probability = sum of probabilities + (fitness / sum)
    sum of probabilities += probability
end for
loop
    until new population is full
        Do this twice
            number = Random between 0 and 1
            for all members of population do
                if number
                    > probability but less than next probability then
                        you have been selected
                    end if
                end for
            create off – spring
        end loop
    
```

2.2 Crossover

The role of crossover in the GA is to combine bits and pieces from fit solutions.

Pseudo Code

```

find a crossover point according to the
    Crossover probability.
for i = 0 to crossover point do
    child A gene[i] = parent A gene[i]
    child B gene[i] = parent B gene[i]
end for
for i = crossover point to chromosome length do
    child A gene[i] = parent B gene[i]
    child B gene[i] = parent A gene[i]
end for
return children
    
```

2.3 Mutation

Similar to crossover, mutation is analogous to biological mutation and used to maintain genetic diversity from one generation to the next. The aim of mutation in GAs is to allow the algorithm to avoid local minima by preventing the population of chromosomes from becoming too similar to each other, thus slowing or even stopping evolution.

Pseudo Code

```

for i = 1 to chromosome length do
    generate a random number Nr
    if Nr < mutation probability then
        child A gene[i] = random value
        child B gene[i] = random value
    end if
end for
    
```

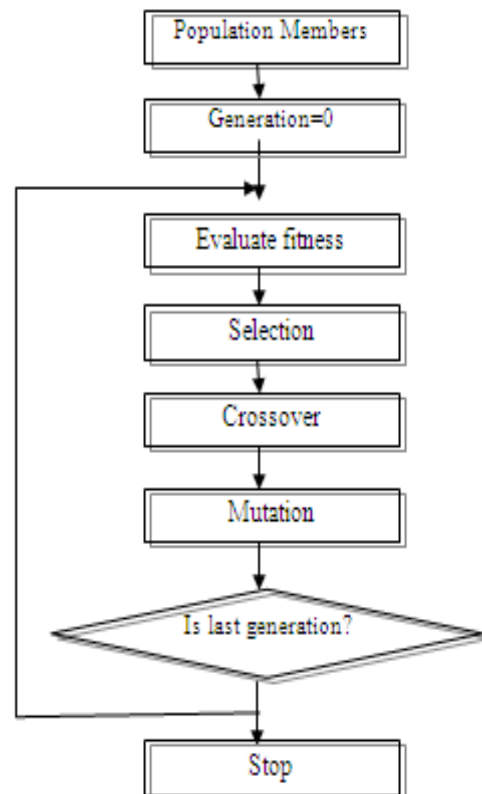


Fig 2: Genetic Algorithm Flowchart

3. NEURAL NETWORK

A neural network is type of connected system in which various neurons are connected to each other. The neural network does not work in linear phase rather it works in parallel manner. Basic architecture of neural network is represented as follows [20]:

The perceptron is the simplest neuron with the help of which working will be discussed as following [21]:

Pseudo Code

Receive inputs

Input i_1, i_2, \dots, i_n

Assign Weights to inputs

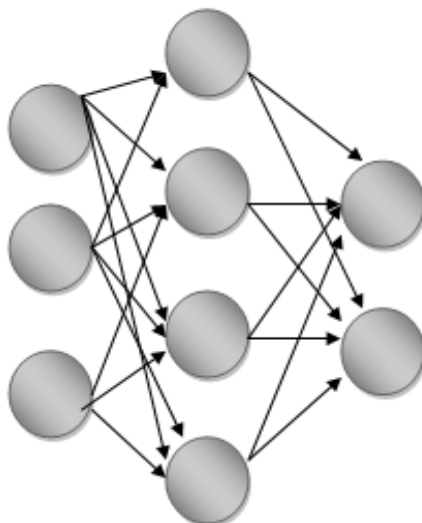
$i_1w_1, i_2w_2, \dots, i_nw_n$

Sum of all the inputs

$i_1w_1 + i_2w_2 + \dots + i_nw_n$

Generate Output

Input Layer Hidden Layer Output Layer



Figur3. Neural Network Architecture

4. COMPUTATION STUDY

As the ECG signals are used for detecting the cardiac diseases and the improvement in ECG feature extraction has become the chief importance for diagnosing the long recording. An ECG signal is a graphical representation of the cardiac activity for computing the cardiac diseases and to check the abnormalities in the heart. The problem of this research work is to classify the disease dataset using Genetic algorithm and train the Neural Network 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 image to be tested. Our research is based on studying the implemented approaches in the ECG diseases and then to propose a new method /algorithm for classification of Sinus Bradycardia and

Tachycardia depend on neural network and the genetic algorithm.

The study is implemented by using the various parameters like false acceptance Ratio (FAR), false rejection rate (FRR) and Accuracy. A system's FAR typically is the ratio of the number of false acceptances to the number of identification attempts. FRR typically is the ratio of the number of false rejections divided by the number of identification attempts and accuracy defines how close a measured value is to the actual value. The steps above shown in the flowchart explained the phase that has been accomplished.

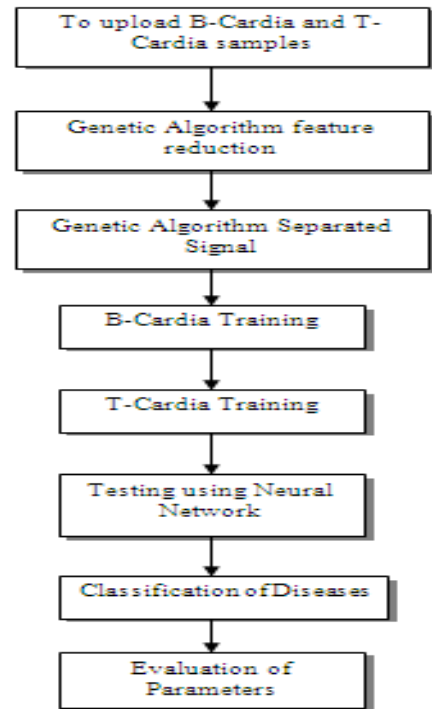


Fig 4: Proposed Flowchart

5. RESULT

The whole implementation has been done in MATLAB environment using GA and NN algorithms.

Table 1: Values of different parameters

Sample s	Disease	FAR	FRR	Accurac y
104	Techacardi a	0.019354	0.00046054	99.9346
106	Bradacardi a	0.009731	0.00034	99.9562
123	Bradacardi a	0.010013	0.00035667	99.9543
219	Techacardi a	0.015644	0.00027277	99.9571

FAR is the measure of the false acceptance rate values in the propsoed work. Its value must be low in order to have good efficiency of the proposed implemented algorithm. From

above figure 5: it has been concluded that FAR values for proposed samples of database are .0193, .0097, .0156 and .0100.

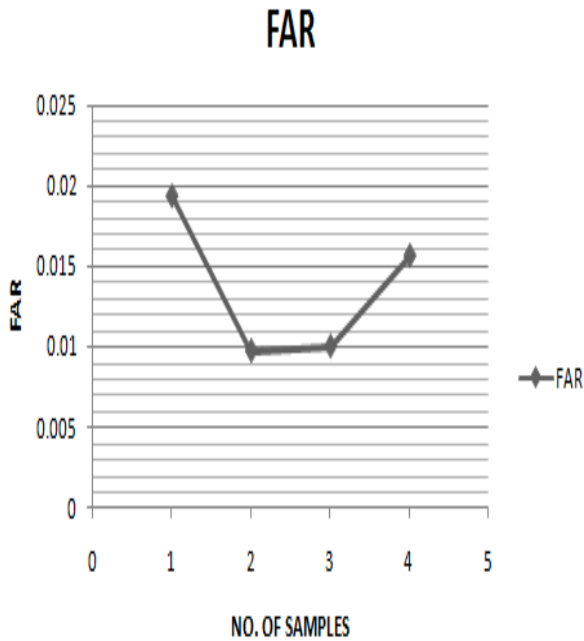


Fig 5: FAR Values

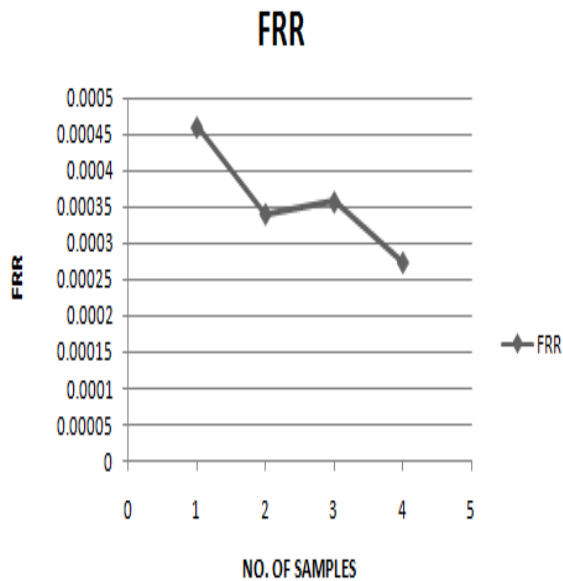


Fig 6: FRR Values

FRR is the measure of the false rejection rate values in the proposed work. Similar to FAR, the FRR values must be low in order to have good efficiency of the proposed implemented algorithm. From above figure 6 : it has been concluded that FRR values for proposed samples of database are .00046, .00034, .00035 and .00027.

ACCURACY

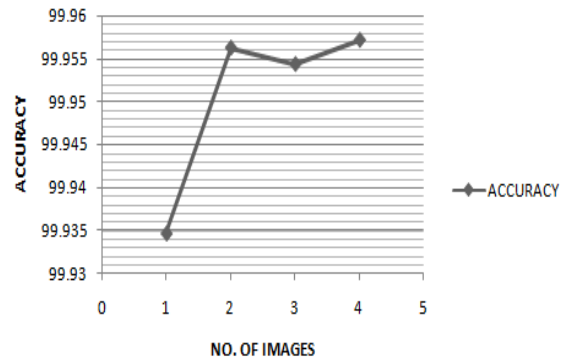


Fig 7: Accuracy Values

The above figure shows the accuracy in terms of FAR and FRR. It can be written as:

$$Accuracy (\%) = (100 - (FAR (\%) + FRR (\%)) / 2)$$

Above figure shows the average accuracy rate of 99.96% using neural network and genetic algorithm. Hence implemented algorithm is better with respect to accuracy.

Table 2: Performance Comparison

Approach	FAR	FRR
Proposed Approach	.0123	.0038
Chiu et.al (DB-1) [22]	.83	.86
Chiu et.al (DB-2) [22]	12.50	5.11

Table 2 shows the performance comparison of our proposed method with several existing method, where our proposed method has a better performance in FAR and FRR. The reason for good FAR and FRR is that the proposed method used combination of genetic algorithm and neural network.

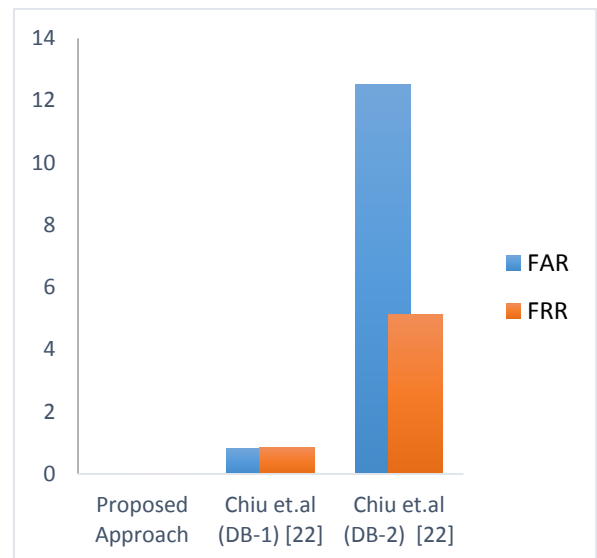


Figure 8. Comparison Graph

6. CONCLUSION

Clinical databases have accumulated large quantities of information about patients and their medical conditions. The term Heart disease encompasses the diverse diseases that affect the heart. Heart disease is the major cause of casualties in the world. The term Heart disease encompasses the diverse diseases that affect the heart. Heart disease kills one person every 34 seconds in the United States. Record set with medical attributes was obtained from any Repository. With the help of the dataset, the patterns significant to the heart attack prediction can be extracted. The ECG Disease Detection System based on Genetic Algorithm and Neural Network, in which detection is based on three parameters accuracy, FAR and FRR is presented in this research. In the end, classification has been done between T-Cardia and B-Cardia diseases. Simulation results shows that the obtained values of FAR, FRR and accuracy for proposed tested image has been found out to be FAR=.0100, FRR= .00010 and accuracy = 99.97%, that are the satisfactory results. Future scope lies in the use of other classifiers like SVM that has multidimensional data and use of feature reduction algorithms genetic algorithm, so that accuracy rate can be enhanced.

7. REFERENCES

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