Diagnosis of Heart Diseases with the Help of a System Using Artificial Neural Network in ECG Signal Analysis

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Abstract- Heart attack medically known as cardiac arrest is a killer disease. It is a felt need to invent a system which saves time between the precise diagnosis and appropriate treatment to the specific heart disease. This researcher has taken up the challenge of managing to devise a system that does 3 functions in a short time. Those functions are i) finding whether a person is suffering from one of the four heart diseases namely, Atrial Fibrillation, Atrial Flutter, Branch Bundle Block and Myocardial Infarction. After locating the exact heart disease, the system calculates the criticality of that disease. The methodology involves three steps: i) Artificial Neural Network (ANN) training process ii) ANN testing process and iii) calculating the criticality of the affected person . The sources of date are *physionet* and *ECG library*. 20 to 25 ECGs are used for training the Neural Network. A total of..... EGCs were given as input into the system and the results give the researcher some insights into the pattern of relationship between factors such as the age of the patient and criticality.

Index Terms- ECG Signal Analysis, Wavelet Transform and Artificial Neural Network, Cascade Feed Forward Back Propagation Network

I. INTRODUCTION

Advancement in technology has resulted in the rapid advancement in the field of medicine. Due to this man has conquered many killer diseases such as plague, cholera and tuberculosis. But heart attack, often causing sudden death, has been brought under control to some extent. Quite a large number of research studies have been carried out on the basis of the various results obtained through Electro Cardio Gram (ECG), Echo Cardiogram, Tread Mill Test and Angiogram.

Heart attack, known as cardiac arrest may suddenly happen to any individual at any point of time. In case, the patient suffers cardiac arrest, he / she should not lose time in taking tests such as ECG and Echocardiogram. The time saved may help the patient to speed up the treatment, thereby saving his/ her life. So, the interface of computer science and cardiology should come forward with devices that do a few steps in the process of diagnosis, within a very short time thereby saving time for the physician to loss time before giving treatment.

II. OBJECTIVES OF THE STUDY

The main objectives of this research is to evolve a system, which will facilitate the Cardiologist or the heart patient is able:

(a) To find out whether the person is suffering from one of the following diseases :
- (i) Atrial Fibrillation (A Fib)
- (ii) Atrial Flutter (A Fl)
- (iii) Bundle Branch Block (BBB)
- (iv) Myocardial Infarction (MI)

(b) To get at the exact heart disease from which the person is suffering and

(c) To measure the extent, to which the person has been affected by that particular kind of disease.

The above diagnosis is achieved on the basis of ECG signal analysis, using Discrete Wavelet Transform (DWT) together with Artificial Neural Network (ANN) and Cascade Feed Forward Back Propagation (CFFBP).

III. DEFINITION OF CONCEPTS

(i) Wavelet Transform

The understanding of the following key concepts is essential for getting across the analysis in this article. Wavelet Transform: A number of alternative time – frequency methods are now available for signal analysis. Of these, the wavelet transform has emerged over recent years as the most favoured tool by researchers for analyzing problematic signals across a wide variety of areas in Science, Engineering and Medicine.

(ii) Artificial Neural Network

An Artificial Neural Network, often just called a neural network, is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases a neural network is an adaptive system that changes its structure during a learning phase. Neural networks are used to model complex relationships between inputs and outputs or to find patterns in data.

(iii) Feed forward neural network

The feed forward neural network was the first and simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. There are no cycles or loops in the network.

IV. METHODOLOGY

The main objectives of this research is to evolve a system, which will facilitate the Cardiologist or the heart patient so that he or she is able:

(a) To find out whether the person is suffering from one of the following diseases at all:
(i) Atrial Fibrillation (A Fib)
(ii) Atrial Flutter (A Fl)
(iii) Bundle Branch Block (BBB) and
(iv) Myocardial Infarction (MI)
(b) To get at the exact heart disease from which the person is suffering and
(c) To measure the extent, to which the person has been affected by that particular kind of disease.

The methodology used here, consists of three major steps viz.
(i) Preprocessing
(ii) ECG Signal Decomposition and
(iii) ANN Training , Testing & Calculation of the Percentage of Deviation

(i) (i) Preprocessing:

The diagnosis is achieved on the basis of ECG signal analysis in which an ECG signal is given as input, for which the preprocessing steps namely, Denoising, Classification and Feature Extraction are done.

DENOISING.

Though a number of filters are available for denoising the Median Filter is chosen for this research work. In this study the given ECG signal is decomposed into different frequency ranges and only specific frequencies like high frequency and low frequencies alone are considered. It was found that the Median Filter was more suitable for extracting the required frequencies for our study.

CLASSIFICATION

The ECG signals will have some cycles (PQRST) repeated after regular intervals. These cycles are analyzed using Signal to Noise Ratio (SNR) method in order to classify the relevant and irrelevant cycles for the study. The method of classification involves selecting one cycle as the reference cycle and the remaining cycles are compared with the selected reference cycle and their SNR is calculated. The same process is repeated with different reference cycles and their respective SNR values are calculated. It was found that some of the cycles , for different reference cycles, have been found to have the same values. From this we can infer that those are the cycles that are of good performance and are the cycles chosen for the study. It was found that those cycles were the ones which gave accurate results in this study. The other cycles are of less importance for this study and can be ignored.

FEATURE EXTRACTION

In this research, the PCA has been used for feature extraction because it shows lots of very minute variations even, precisely, which is very much needed for this research. The output signal got, using this method can be used directly as an input to the system.

(ii) ECG Signal Decomposition:

The ECG signal after undergoing the preprocessing stages, will become noise-free signals. Those signals are then decomposed into different frequencies, from which the desired frequencies can be filtered and those of interest for the research work are separated. For decomposing the given ECG signal, the Discrete Wavelet Transform has been applied. The DWT 1D was found to be more effective for this study because the decomposition was done very effectively and also the required frequency levels, namely the high- high (HH)frequencies and low- low(LL) frequencies were decomposed using DWT 1D Filter Banks .

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Figure.1 gives the decomposed signal after applying DWT to the input signal.

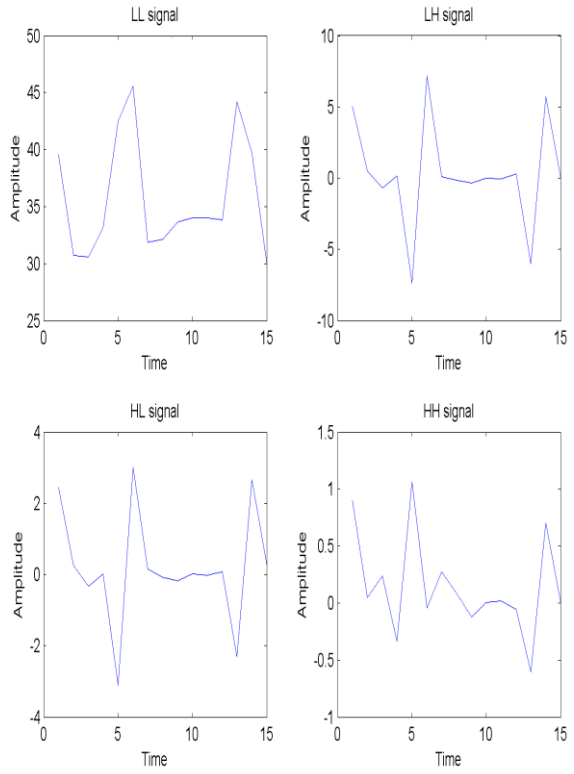


Figure. 1 The Decomposed wavelet using DWT

(iii) ANN Training & Testing & Calculation of the Percentage of Deviation:

The Discrete Wavelet Transform is applied to the ECG signal and the resultant coefficients would be of two frequency ranges Low - Low(LL) and High - High(HH). The input coefficients as well as the target coefficients are given as input the Cascade Feed Forward Neural Network. The training function used here is Levenberg - Marquardt function and also the Performance analysis function chosen here is the Mean Square Error (MSE) . The Transfer function used is the Tan

sigmoid function which is a mathematical modeling function and is automatically derived by the trained network. The number of neurons is also given as input and in this study the number of neurons is 6, because the system gave its best performance with 6 neurons.

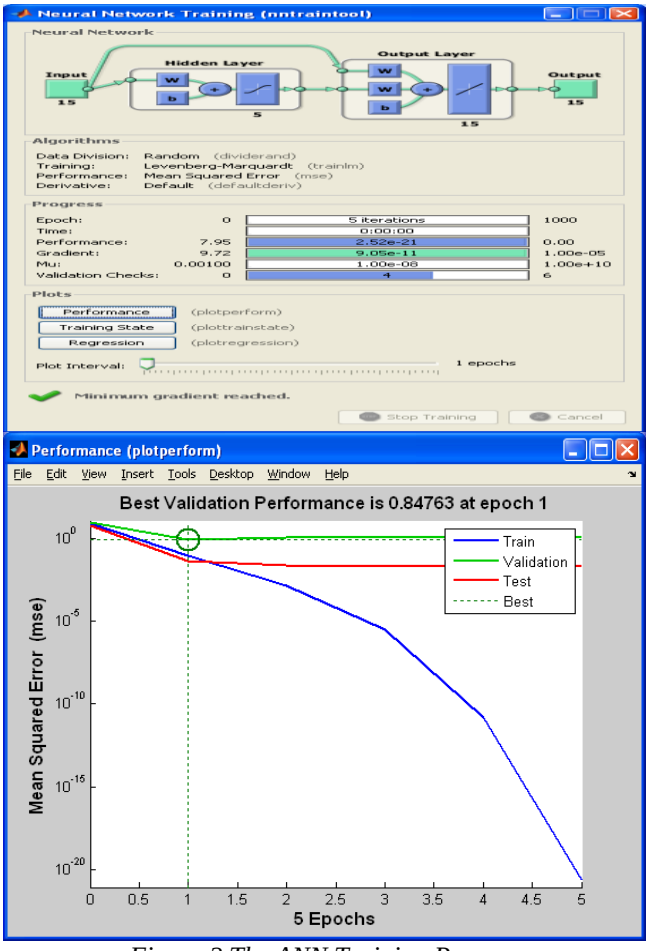


Figure.2 The ANN Training Process

STEPS IN THE TRAINING PROCESS:

1. Two trained networks are created for LL_N and HH_N frequencies for the normal person's ECG signals giving the required inputs.

2. Create 8 trained neural networks for , 2 each (one for LL and one for HH) for the four diseases that are considered for the diagnosis by the system namely *ATRIAL FIBRILLATION, ATRIAL FLUTTER, BUNDLE BRANCH BLOCK* AND *MYOCARDIAL INFARCTION*. These 8 networks are created for finding out if the input signal given is of a normal person or of an affected person.

3. After training the 10 networks, The Query LL signal (LL_Q) is given as input to the trained normal person's network LL_N . The network calculates the Mean Square Error comparing LL_Q and the LL_N using the following formula ,

$MSE = Mean (LL_Q - LL_N)^2$

The system is designed allowing a threshold of 0.3 (ie. 30% error is allowed because almost even normal persons' may have 30% to be affected which can be treated to be normal), which means that above 0.3 indicated that the person is affected by some disease.

If MSE < 0.3 ----- NORMAL PERSON
If MSE > 0.3 ---- AFFECTED PERSON

4. If MSE > 0.3, then the same LL_Q is given as input to LL_{AFIB} , LL_{AFLU}, LL_{BBB}, LL_{MI} and their respective MSEs are calculated. The network which has the least MSE value is the best match , which means that they are almost similar and that is the disease the person is suffering from.

5. If the least MSE was for the disease say, MI, then the HH_Q (now the high - high frequencies) of the query ECG is given as input to the trained network of normal persons and the MSE_N (Normal persons MSE) is calculated.

6. The HHQ is now compared with the HHMI and the MSE_A(Affected Persons MSE) is calculated.

7. The Percentage of Deviation from the normal is calculated using the formula

$$\textbf{\% of Deviation} = \frac{MSE_A}{MSE_N} \times 100$$

The HH is chosen for finding the percentage of deviation because even the smallest variations are recorded very clearly in the HH frequency domains.

V. RESULTS & DISCUSSION

The Figure.3 depicts how the neural network reports the diagnosis of the disease. and its percentage of deviation from the normal ECG signal which may help the doctor predict the criticality of the patient and give him priority of treatment..

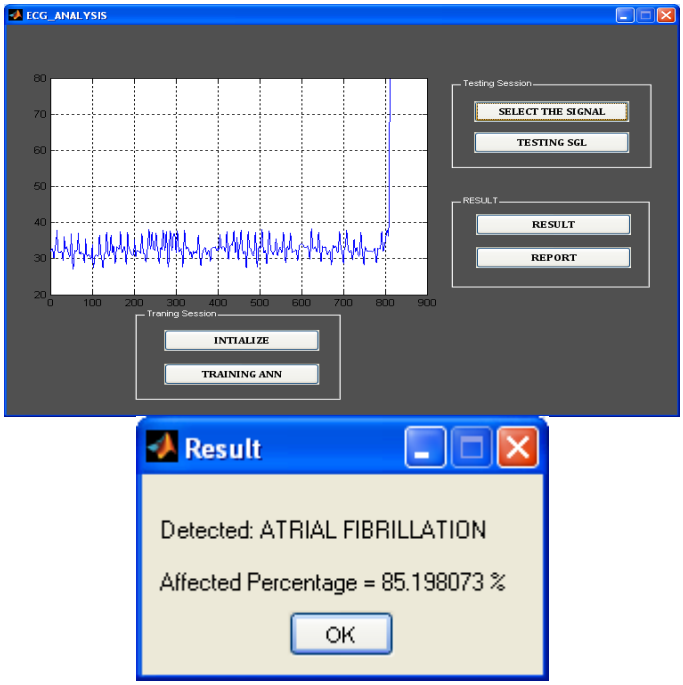
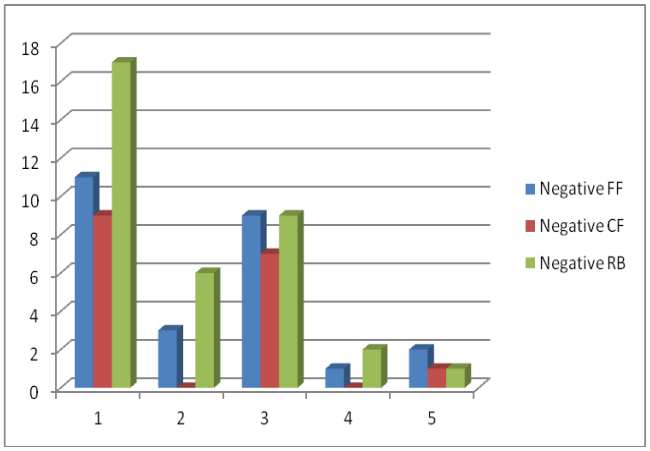


Figure. 3 The Diagnosis of the disease

The Cascade Feed Forward Neural network is used for training and testing the network. Three other algorithms namely, Feed Forward Neural Network and Radial Basis networks were also used for training the neural network but the Cascade Feed Forward network performed well when compared to the other 3 algorithms.

The positive and negative results produced by all the algorithms are depicted in the Figure.4.



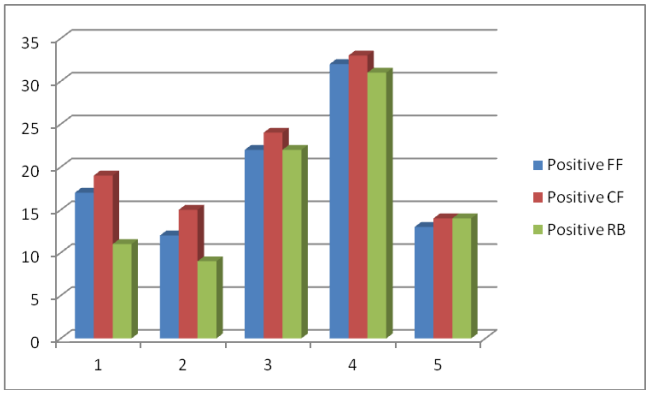


Figure.4 The CFFNN performance comapred with other networks

VI. CONCLUSION

This research is limited to only 4 specific heart diseases. If further research is taken up, more number of diseases may be diagnosed in a short time so that the diseased person can be attended to immediately. This kind of system will, no doubt, be a powerful tool in the hands of the healthcare personnel in their life saving mission.

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