ECG Analysis Using Wavelet Transform and Neural Network

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Abstract : In this work ,we have made an algorithm to classify and detect different types of Electrocardiogram (ECG) signal beats including normal beats(N), premature ventricular contraction (PVC),ventricular tachycardia(VT),super ventricular (SV) and others. Various preprocessing stage are applied to create a new and perfect input vector for the neural classifier. In order to extract feature from electrocardiogram (ECG) signal DWT (direct wavelet transform) is applied. Finally the MIT-BIH database is used to assess the suggestive algorithm. The overall classification accuracy rate is more than 99%..

Keywords:-Electrocardiogram (ECG), Artificial Neural Network (ANN), wavelet Transform.

I. INTRODUCTION.

Arrhythmias are difficulties that damage the pumping action of the heart muscle, creating unusual heart rhythms. Interpretation of ECG is the most crucial upcoming areas and broadly clinical tools. [2]. In this process the signal is measured in human body surface, which is used recognition of the cardiovascular diseases. Any problem of rhythm or change in morphological pattern or heart rate is a warning of cardiac arrhythmia which can be marked by examination of recorded electrocardiogram (ECG) waveform. The electrocardiogram (ECG) as shown in Fig.1. Denotes the electrical impulses of the heart. Normally the range of frequency on electrocardiogram (ECG) signal is of 0.05- 100 HZ. And it's dynamic range of 1-10 mv. One cardiac cycle is an ECG signal containing P-QRS-T waves. Most of the important and functional details in the electrocardiogram is produce in the amplitude and interval describes by its characteristics [4]. The motive of this work is to create an effective algorithm to solve problems linked with recognition of arrhythmia. In order to do so give aspects of ECG analysis are taken for discussion.

1) For time frequency analysis wavelet transform is very effective technique. By decomposing signal in basic components which are properly localized both in frequency and time [1] [2]. WT can be used to differentiate serious noise from ECG waves, artifacts, and baseline drift. Therefore to extract the information from ECG signal wavelets are used.
2) A supervised ANN is implemented to recognize and differentiate the nonlinear morphologies. Supervised learning needs standard data while training, hence recordings of ECG from MIT-BIT. Arrhythmia data with a sample frequency of 360 HZ are employed in this work.

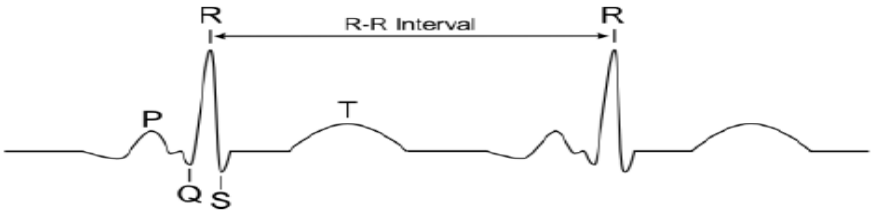

Fig.1: ECG Wavefom

II. MATERIALS

2.1 Wavelet Transform

Wavelet transform is a convolution of the wavelet function x $\psi(t)$ with the signal $x(t)$. The orthonormal dyadic different wavelets are linked with scaling functions $\phi(t)$.The scaling function can be convolved with the signal to produce approximation coefficients. The discrete wavelet transform (DWT) can be written as

$$T_{m,n} = \int_{-\infty}^{\infty} x(t)\psi_{m,n}(t)dt \qquad (1)$$

By choosing an orthonormal wavelet basis $\psi m,n(t)$ we can reconstruct the original. The coefficient approximation of the signal at the location *n*and scale *m* can be written as

$$S_{m,n} = \int_{-\infty}^{\infty} x(t)\phi_{m,n}(t)dt \qquad (2)$$

But the input signal is of definite length *N*. So the range of scales that can be seen is $0<m<M$. Hence a discrete approximation of the signal can be written as

$$x_o(t) = x_M(t) + \sum_{m=1}^{M} d_m(t) \qquad (3)$$

where the mean signal approximation at scale *M* is $xM(t) = S_M$, $n\phi M,n(t)$ and detail signal approximation corresponding to scale *m*, for finite length signal is given by

$$d_m(t) = \sum_{n=0}^{M-m} T_{m,n}\psi_{m,n}(t) \quad (4)$$

The signal approximation at a specific scale is a combination of the approximation and detail at the next lower scale.

$$x_m(t) = x_{m-1}(t) - d_m(t) \quad (5)$$

Presently Daubechies [6] wavelet is chosen though the Daubechiesalgorithm is more complex and has a some complicated computations, then also this algorithm picks up fine details that are missed by other wavelet algorithms, like Haar wavelet algorithm. Even if a signal is not represented well by one member of the Daubechies family, it may still be efficiently represented by another.

2.2 Wavelet analysis

The wavelet examination of ECG signal is carry out by using MATLAB software. MATLAB is a high interactive system which allows solving many technical data processing problems. The MATLAB is provided with wavelet tool box. It has a functions built on the MATLAB technical computing environment. It gives tools for the analysis and synthesis of signals and images using wavelets and wavelet packets within the MATLAB domain. [10]

III.METHOD

The work is carried out to identify and classify the normal beats and arrhythmias available in the ECG record. The implementation steps are described as follows.

1. The ECG signal preprocessing is carried out for removing noises and Base line wandering
2. To identify the Feature of ECG signal and its feature extraction by wavelet.
3. To design back propagation neural network for classification of arrhythmias.
4. To implement neural network for classification of beats into distinct classes Normal beat (N), PVC beat, VT, SV and others.

3.1 Preprocessing of signal by median Filtering

In signal processing, it is necessary to carry out some kind of noise removal techniques for a signal. The median filter is a nonlinear digital filtering techniques, a lot worn to eliminate the noise. Such noise removal process is a typical pre-processing pace to advance the results of coming procedure. Median filters are used in digital signal processing because ,under certain circumstances, it guards edges while eliminating the noise.[16] In this paper it is used to eliminate the baseline drift noise in the MIT-BIT database ECG signal, which gives better result of later processing. The median filter output shown in figure 3.

3.2 DWT approach

In this arrhythmia database used. The sampling frequency of record is 250HZ. The maximum frequency component decides the number of decomposition level. The decomposition levels are selected on that part of the signal that correlate mostly with the frequency required for the classification of the signal are keep in the wavelet coefficient. In this work the number of decomposition level are chosen to be 2. MATLAB Wavelet Toolbox provides various different Wavelet function for signal decomposition.

3.3 Classifier Neural network

Back propagation is a most important method for training multilayer ANNs and it can easily provides a method for which changing the weights in a feed forward neural network depending on activating function. The mostly back propagation Neural Network is used as a decision maker for classifying arrhythmias.

The Artificial Neural Networks (ANN) is the tools, which can be used as processing element as a neural biology using mathematical operations. A neural network is characterized by its pattern of connections between the neurons (called its architecture), its training, or learning algorithm, and its activation function [17]. The Multilayer Perception (MLP) is the most common supervised neural network. The purpose of the MLP is to design a model that correctly maps the input data to be used to produce the output results when the desired output is unknown.

In the first step, the MLP is used to learn the behavior of the input data using back-propagation

Algorithm. This step is called the training phase. In the second step, the trained MLP is used to test using unknown input data. The back-propagation algorithm implements expected results. This kind of classification is called supervised classification. The MLP computes the error signal using the obtained output and desired output. The computed signal error is then fed back to the neural network and used to

Adjust the weights such that with each iteration the error decreases and the neural model gets to produce the desired output.

There are various training algorithms, to evaluate the fastest performance of training algorithm by considering the complexity of the problem, the number of data points in the training set, the number of weights, and biases in the network, and to determine error goal.

IV. RESULTS

In the present work 10 ECG records with normal beats and different types of arrhythmias are selected from the MIT-BIH arrhythmia database 15]. Only one channel ECG signal with half an hour long was considered and the annotated information of the test data shown in the Table I is used as reference for evaluating the performance of the proposed methods. The effectiveness of proposed method was determined by the Accuracy of an ECG classifier [6] is given as:

$$Accuracy = \frac{\text{Total number of beats correctly classified}}{\text{Total No. of Beats Tested}}$$

Using MATLAB R 2013 a.The overall classification was done using Neural Network Classifier. The design of the system is depicted in fig. 2

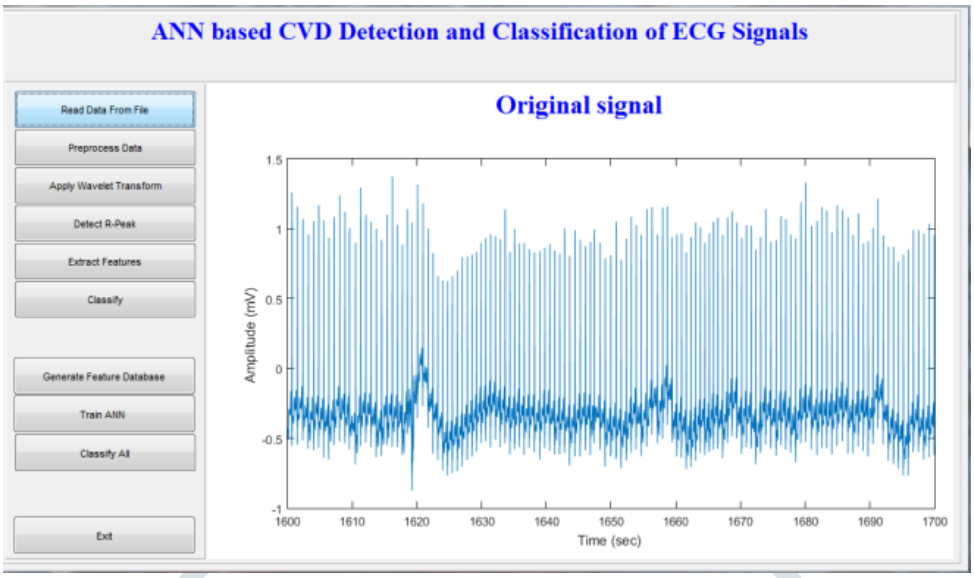

Fig. 2: GUI Design for detection of arrhythmia using ECG.

Figure 3 shows the sample of filtered and normalized ECG signals.

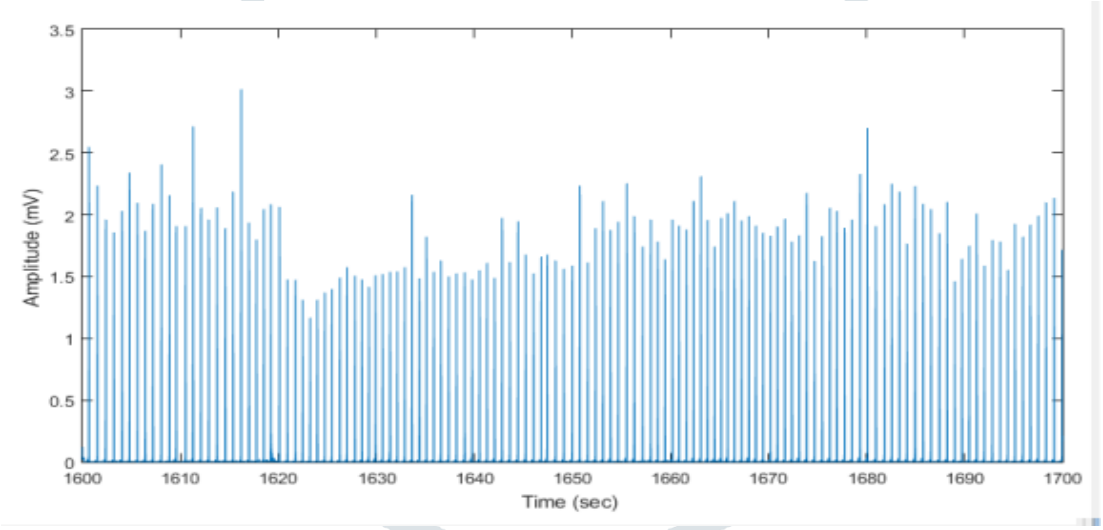

Fig 3: Normalized Signal

Fig. 4 shows the sample of R-Peak detection for ECG signal

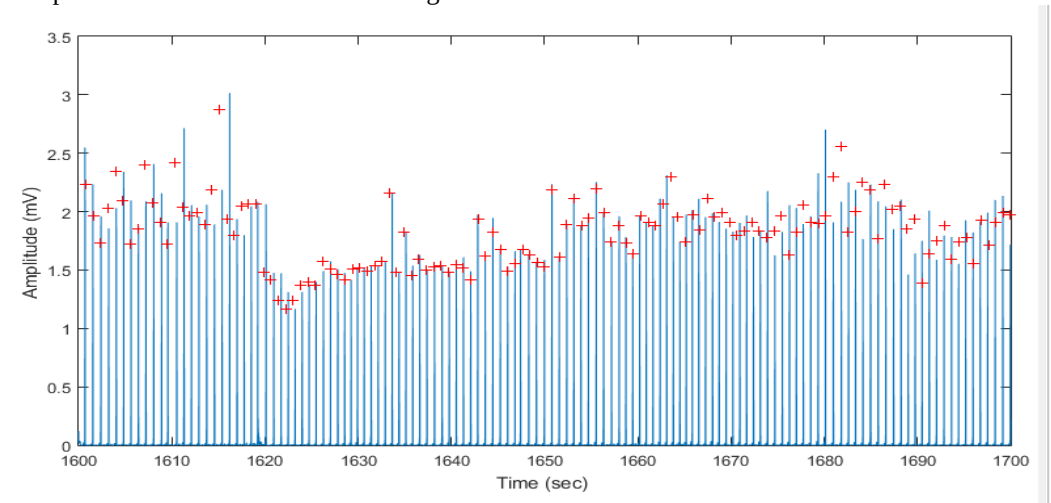

Fig. 4: R-peak detection

Table 1: Performance of the NN Classifier

Record	MIT-BIH Normal	NN Normal	MIT-BIH PVC	NN PVC	MIT-BIH VT	NN VT	MIT-BIH SV	NN SV	Accu-racy%
100	124	123	-	-	-	-	-	-	99.19
101	98	98	-	-	-	-	-	-	100
210	127	123	14	10	-	-	-	-	96.85
219	116	115	05	04	-	-	-	-	99.13
104	06	05							83.33
109	-	-	05	04					80
111	-	-	-	-	02	01			50
221	123	122	08	08	-	-	-	-	99.18
228	86	84	23	16	-	-	-	-	97.67
234	147	147	-	-	-	-	-	-	100

Table 2: Classification and accuracy for Arrhythmic Data Set (NN Classifier)

Observation	Normal Beat	PVC Beat	VT Beat	SV Beat	Total
Total No. of Beats	827	55	02	--	884
Correctly Classified	817	42	01	--	860
Unclassified	02	13	01	--	24
Overall Accuracy					97.28%

V .CONCLUSION

In this work an arrhythmia classification system using ECG signals based on Artificial Neural Network and wavelet transform is presented. Using wavelets (db6) ECG signals is decomposed and then its features are extracted. Which gives the accurate and precise change in the shape of ECG compared with the other transform domains a high quality of feature set is important factor for good performance of ECG analysis algorithms? In this approaches, `db6' wavelet takes care of the discontinuities at the edges. The selected features from the wavelet transform are given as input to the supervised back propagation neural network for classification. The accuracy is found to be 97%

VI .ACKNOWLEDGMENT

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References:

[1] C. Li, C. Zheng, and C. Tai, “Detection of ECG characteristic points using wavelet transforms,” IEEE Trans.Biomed.Engg. vol. 42, pp. 21- 28, 1995

[2] S.Z.Mahmoodabai,A.Ahmadian “ECG Feature Extraction Based on Multi resolution Wavelet Transform” Proceeding of the 2005 IEEE Engineering in Medicine & Biology 27th Annual Conference,Shanghai,China,Sep 1-4,2005

[3] C.J.Chang “Time Frequency Analysis & Wavelet Transform Tutorial”.

[4] B. Anuradha and V. C. Veera Reddy “ANN FOR CLASSIFICATION OF CARDIAC ARRHYTHMIAS”ARPN Journal of Engineering and Applied Sciences, VOL. 3, NO. 3, JUNE 2008

[5] Ying-Hsiang Chen and Sung-Nien Yu” Comparison of Different Wavelet Subband Features in the Classification of ECG Beats Using Probabilistic Neural Network “Proceedings of the 28th IEEE EMBS Annual International Conference New USA, Aug 30-Sept 3, 2006

[6] Y. Sun, Arrhythmia Recognition from ECG using Non-linear Analysis and Unsupervised Clustering Techniques. PhD thesis, Nanyang Technological University, 2001.

[7] K. Minami, H. Nakajima, and T. Toyoshima, “Real-time discrimination of ventricular tachyarrhythmia with Fourier-transform neural network," IEEE Trans. Biomed.Eng., vol. 46, Feb 1999.

[8] Z. Dokur, T. Olmez, and E. Yazgan, “Comparison of discrete wavelet and Fourier transform for ecg beat classication," in Electronics Letters, vol. 35, pp. 1502-1504,Sep 1999.

[9] The wavelet Tutorial by RobiPolikar.

[10] Wavelet Toolbox from MATLAB 7.0.

[11] Neural Network Toolbox from MATLAB

[12] S.Z. Mohmoodabadi, A. Ahmadian, M.D. Abolhasani (2005) ECG feature extraction using Daubechies wavelets, Proc. of the fifth IASTED International Conference, Benidorm, Spain.
[13] ECG Signal Analysis Using Wavelet Transforms by C. Saritha, V. Sukanya, Y. Narasimha Murthy

[14] International Journal of Computer Science, Engineering and Applications (IJCSEA) Vol.2, No.1, February 2012, Classification of ECG Arrhythmias using discrete Wavelet Transform and Neural Networks. MaedehKianiSarkaleh and AsadollahShahbahrami.
[15] ECG signal analysis using Hilbert Transform 2015 IEEE Power, Communication and Information Technology Conference (PCITC).