

## Classification of Heart Rate Using Back Propagation Neural Networks

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### Abstract

*A condition of abnormal electrical activity in the heart which is a threat to humans is shown by this electrocardiogram. It is a representative signal containing information about the condition of the heart. The of the P-QRS-T wave shape and size and their time intervals between its various peaks these are all contain useful information about the nature of disease affecting the heart. This paper presents a technique to examine electrocardiogram (ECG) signal, take out the features for the heart beats classification. Collect data from MIT-BIH database. The heart rate is used as the base signal from which certain parameters are extracted and presented to the BPN for classification.*

**Keywords**---MIT-BIH, ECG, QRS complex.

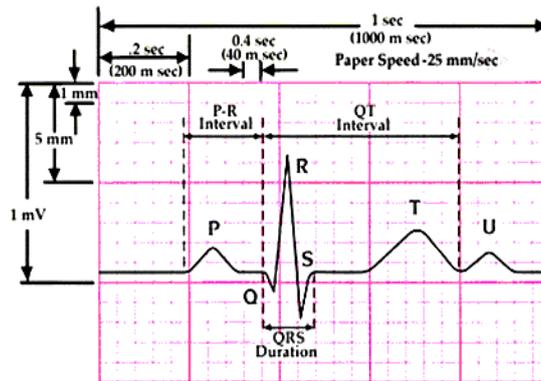
### 1. Introduction

Today signal processing plays a major role in ECG signal analysis and interpretation. The aim of ECG signal processing is diverse and comprises the improvement of measurement accuracy and reproducibility (when compared with manual measurements) and the taking out of information not readily available from the signal through visual assessment. In various situations the signal is recorded during ambulatory or strenuous conditions such that the signal is corrupted by different types of noise sometimes originating from another physiological process of the body. Therefore noise reduction represents another important objective of ECG signal processing. [1]

Electrocardiography deals with the electrical activity of the heart signal. It is monitored by placing sensors at the limb extremities of the subject; it is a record of the origin and propagation of the electric potential through cardiac muscles. It is very useful in diagnosing cardiac disorders by their signal representation. Cardiac health is generally reflected by their shape of ECG waveform and heart rate production. It may contain important pointers to the nature of diseases affecting the heart.

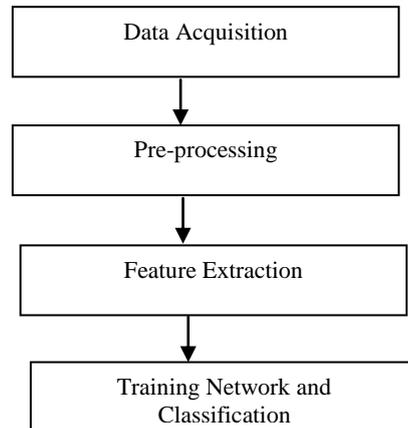
A number of techniques have been devised by the researchers to detect the characteristics in ECG [2]-[5]. Recently wavelet transform has been proven to be useful tool for non-stationary signal analysis. The wavelet transform based technique can be used to identify the characteristic features of the ECG signal to a reasonably good accuracy, even with the presence of high frequency and low frequency noises. Among the existing wavelet approaches, (continuous, dyadic, orthogonal, biorthogonal) we use real dyadic wavelet transform because of its good temporal localization properties

**Figure 1. Structure of ECG Waveform**



## 2. Methodology

The block diagram in figure 2 explains the overall methodology for the classification of the heart rate used in this work. The overall works have various steps like data acquisition, pre-processing, feature extraction and finally neural network training.



**Figure 2. Block Diagram**

### a) ECG Data Acquisition:

MIT-BIH database was used in this work for training and testing. Totally 35 records of database are collect from MIT-BIH. The MIT-BIH Arrhythmia Database contains 48 half-hour excerpts of two-channel ambulatory ECG recordings, obtained from 47 subjects studied by the BIH Arrhythmia Laboratory between 1975 and 1979. The recordings were digitized at 360 samples per second per channel with 11-bit resolution over a 10 mV range. [6]

### b) ECG preprocessing.

The digitized ECG contains many types of contaminations; especially noises are present in the signal. So before go to the detection of their peak and their time interval, require preprocessing. In this paper two types of filter are used to remove the noise in the signal. First one median filter and another one is finite impulse response filter.

#### Median filter

The median filter is a nonlinear digital filtering method, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, access by access, over the intact signal. For 1D

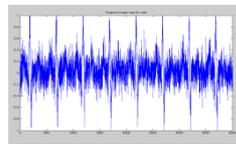
signals, majority obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals. Purpose of digital median filter is smoothing signals by taking the median of odd number of continuous sampling points [7]. The median filter thus uses both past and future values for predicting the current point.

#### *FIR filter*

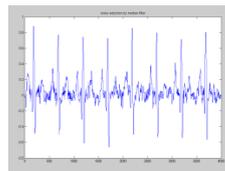
FIR filter are widely used due to the powerful design algorithms that exist for them, their natural stability when implement in non-recursive form, there is no difficulty with which one can attain linear phase, their simple extensibility to multi rate cases, and the sample hardware support that exists for them among other reasons. In order to determine a suitable filter order, FIR is essential to specify the amount of pass band ripple and stop band attenuation that will be tolerated. Then also it specifies the width of the transition region around the ideal cutoff frequency. After that is done by setting the pass band edge frequency and the stop band edge frequency.[7]

Three well-known methods for FIR filter design namely:

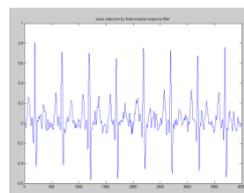
1. The window method
2. The frequency sampling technique
3. Optimal filter design methods



(a) Original image



(b) Noise reduction using Median filter



(c) Noise reduction using Frequency response filter

### **Figure 3. Preprocessing Output**

#### *c) Feature extraction*

##### *a) Wavelet transform*

Wavelet transform is a time scale representation that has been used successfully in a broad range of applications, in particular signal compression. Recently, Wavelets have been applied to several problems in Electro cardiology, including data compression, analysis of ventricular late potentials, and the detection of ECG characteristic points. The Wavelet transformation is a linear operation that decomposes the signal into a number of scales related to frequency components and analyses each scale with a certain resolution. The WT uses a short time interval for evaluating higher frequencies and a long time interval for lower frequencies. Due to this property, high frequency components of short duration can be observed successfully by Wavelet Transform. One of the advantages of

the Wavelet Transform is that it is able to decompose signals at various resolutions, which allows accurate feature extraction from non-stationary signals like ECG. A family of analyzing wavelets in the time frequency domain is obtained by applying a scaling factor and a translation factor to the basic mother wavelet.

Wavelet transform of a signal  $f(t)$  is defined as the sum of over all time of the signal multiplied by scaled, shifted versions of the wavelet function  $\psi$  and is given by

$$w(a, b) = \int_{-\infty}^{\infty} f(t) \varphi_a, b(t) dt \quad (1)$$

$$\varphi_a, b(t) = \frac{1}{\sqrt{a\varphi^n}} \left( \frac{t-b}{a} \right) \quad (2)$$

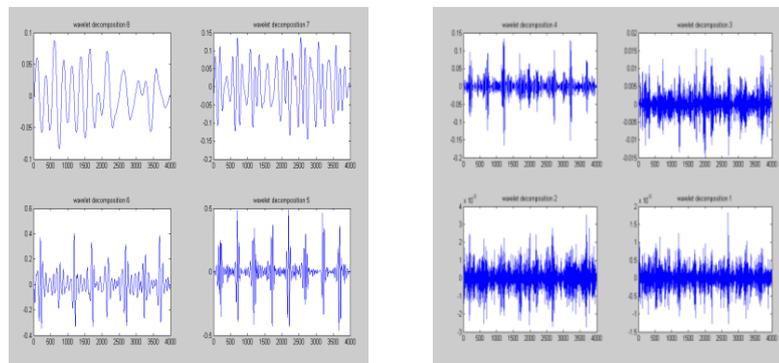
The DWT is sufficient for most practical applications and for the reconstruction of the signal. The DWT provides enough information, and it gives a significant reduction in the computation time. Here, we have discrete function  $f(n)$  and the definition of DWT is given by:

$$w(a, b) = c(j, k) = \sum_{n=z} f(n) \omega_{j,k(n)} \quad (3)$$

Where  $\varphi_{j,k(n)}$  is a discrete wavelet transform

$$\varphi_{j,k(n)} = 2^{\frac{j}{2}} \varphi(z^{-j}n - k) \quad (4)$$

In the DWT analyses, the signal at different frequency bands and at different resolutions is decomposed into a 'coarse approximation' and 'detailed information'. Two sets of functions are employed by the DWT, the scaling functions (associated with the low pass filter) and the wavelet functions (associated with the high pass filter). The signal is filtered by passing it through successive high pass and low pass filters to obtain versions of the signal in different frequency bands. The fundamental idea behind wavelets is to analyze according to scale. These are functions that satisfy certain mathematical requirements and are used in representing data or other methods. It algorithms process data at different scales or resolutions. If the signal with a large window, we would notice gross features. Also signal with a small window, then notice that have a small feature.



**Figure 4. Eight Level of Wavelet Decomposition**

*b) Detection of peak and their intervals.*

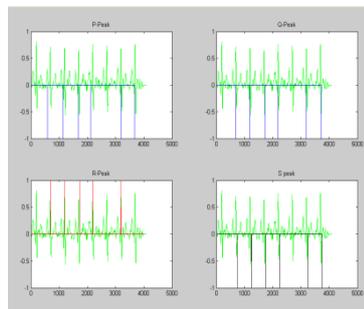
The ECG records the electrical activity of the heart, where each heart beat is displayed as a series of electrical waves characterized by peaks and valleys. It gives two kinds of information. First duration of the electrical wave crossing the heart which in turn decides whether the electrical activity is normal or slow or irregular and the second is the amount of electrical activity passing through the heart muscle which enables to find whether the parts of the heart are too large or overworked.

Normally, the frequency range of an ECG signal is of 0.05–100 Hz and its dynamic range – of 1–10 mV. The ECG signal is characterized by five peaks and valleys labeled by the letters P, Q, R, S, T. And also use another peak called U. The presentation of ECG analyzing system depends mainly on the accurate and reliable detection of the QRS complex, as well as T- and Pwaves. Representation of the P-wave is the activation of the

upper chambers of the heart called atria, Then the lower chamber of the heart or excitation of the ventricles is represented by QRS complex and T-wave . The most important task is the detection of the QRS complex. Once the QRS complex has been identified a more detailed examination of ECG signal including the heart rate, the ST segment etc. can be performed [8]

In the normal sinus rhythm (normal state of the heart) the P-R interval is in the range of 0.12 to 0.2 seconds. The QRS interval is from 0.04 to 0.12 seconds. The Q-T interval is less than 0.42 seconds and the normal rate of the heart is from 60 to 100 beats per minute. So, from the recorded shape of the ECG, we can say whether the heart activity is normal or abnormal.

The electrocardiogram is a graphic recording or display of the time variant voltages produced by the myocardium during the cardiac cycle. P, QRS and T wave T-waves reflect the rhythmic electrical depolarization and repolarization of the myocardium associated with the contractions of the atria and ventricle.



**Figure 5. Detection of PQRST Waveform**

**Table 1. Amplitude Value For waves**

Wave	Amplitude value
P-wave	0.25mv
R-wave	1.60mv
Q-wave	25%R wave
T-wave	0.1 t0 0.5mv

**Table 2. Time Interval Between their Wave**

Wave	Duration
P-R interval	0.12 t0 0.20s
Q-T interval	0.35 to 0.44s
S-T interval	0.005 t0 0.15s
P-wave interval	0.11s
QRS interval	0.09s

Intervals are done by subtraction from last to front of the intervals. For example ST duration interval are done by length of T wave minus length of S wave and divided by 360.

*c) Detection of QRS complex.*

In order to detect the peaks, specific details of the signal are selected. The detection of R peak is the first step of feature extraction. The R peak in the signal from the Modified Lead II (MLII) lead has the largest amplitude among all the waves compared to other leads. The QRS complex detection consists of determining the R point of the heartbeat, which is in general the point where the heartbeat has the highest amplitude.

A normal QRS complex indicates that the electrical impulse has progressed normally from the bundle of His to the Purkinje network through the right and left bundle branches and that normal depolarization of the right and left ventricles has occurred. Most of the energy of the QRS complex lies between 3 Hz and 40 Hz. In this paper that the

contribution work of Detection of QRS complexes are done by differentiates the input signal. Differences and approximate derivatives are using in the input signal. That the diff (input signal) calculates differences between adjacent elements of input signal. If input signal is a vector, then diff (input signal) returns a vector, one element shorter than input signal, of differences between adjacent elements

[Input signal (2)-input signal (1) input signal (3)-input signal (2) ... input signal (n)-input signal (n-1)]

If an input signal is a matrix, then diff (input signal) returns a matrix of row differences:

[Input signal (2: m, :)-input signal (1: m-1, :)]

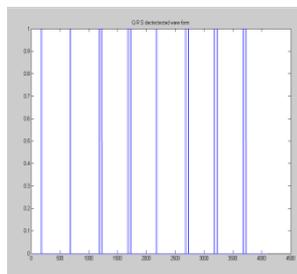
Cumulative of 1st and 2nd differentiation and fixing threshold to find QRS complex that is peak point. Threshold value are obtained by

Threshold=absolute (maximum (cumulative (input signal)));

Then, Threshold= Threshold/2;

For x=1: length (input signal)

If input signal(x) greater than threshold QRS complex(x) ==1. Otherwise QRS complexes (input signal) ==0;



**Figure 6. Detection of QRS Wave Form**

Finding the Heart rate value from this QRS complex. That the blue line in figure 6 shows the QRS complex value, extract that the value. And find out the length of the total value and divided by 2 and multiply with 5 for 60 seconds. Then we obtain the heart rate for the signal.

#### *a) Training Network*

Then the classification is done by Back Propagation Network. The learning algorithm multilayer perceptions requires a differentiable activation function, frequently is logistic function used (non-linear, monotonic, increasing, differentiable). The term back propagation means the backward propagation of an error signal through the network. After propagating a pattern through the network - feed forward, the output pattern is compared with a given target and the error of each output unit is calculated. This error is propagated backwards to the input layer - back propagation. Finally the errors of the units are used to modify the weights.

The back-propagation neural network (BPNN) allows practical acquirement of input/output mapping information within multilayer networks. BPNN executes the gradient descent search to minimize the mean square error (MSE) between the desired output and the actual output of the network by adjusting the weights. Back propagation algorithm is highly precise for most classification problems for the reason that the characteristics of the generalized data rule [9-10].

It is a forward multi-layer network, which uses the error back-propagation algorithm to train the network. BP algorithm was proposed by Rumelhart et al in 1986, while due to simple structure, multiadjustable parameters, much training algorithm and good operational performance by these are all this network got a wide range of practical application. The network structure of the three-layer BP neural network is shown in

Figure 6; from that figure this neural network contains an input layer and middle layer (hidden layer) and an output layer. In this complete connectivity between the upper and lower layers and there are no connections between neurons in each layer. That the input layer of the signal needs to spread towards to hidden layer nodes and transformed by the function, then transmission of the input signal of hidden layer nodes to the output layer nodes. Typically that the transfer function of BP neural network is Sigmoid Type differentiable function, which can attain random non-linear mapping between the input and output, from this result this type of network has been widely applied in pattern recognition, function approximation and other areas. [11]

## 2. Results and Discussion

That the data base are collected from MIT-BIH. In this paper 34 signals are used for training and from this 15 signals are taken for testing.

**Table 3. Classification Results**

Test Data	Desired Output	Output Characterization
sigcor1	Normal	Normal
signal126_1	Normal	Normal
toydata	Normal	Normal
M100ECG	AbNormal	Abnormal
M103ECG	Abnormal	Abnormal
toydata_test	Normal	Normal
M104ECG	Abnormal	Abnormal
M105ECG	Abnormal	Abnormal
signal126_2	Normal	Normal
M107ECG	Abnormal	Abnormal
M111ECG	Abnormal	Abnormal
M112ECG	Abnormal	Abnormal
M113ECG	Abnormal	Abnormal
M124ECG	Abnormal	Abnormal
GoldStandard	Normal	Abnormal

Our methods achieves the discrimination between normal and abnormal heart rate, these are diagnosis by back propagation neural network. Our method proves real time application performance parameter can accurately judge that the accuracy.

**Table 4. Performance Parameters**

Technique used	Specificity	Accuracy
BPN Neural Network	100%	93.3%

## 3. Conclusion

ECG signals required for analysis are collected from Physionet MIT-BIH arrhythmia database where annotated ECG signals are described by a text header file (.hea), a binary file (.dat) and a binary annotation file (.atr). The database contains 48 records, each containing two-channel ECG signals for 30 min duration selected from 24-hr recordings of 47 different individuals. The methods were developed under MATLAB.

Since the application of wavelet transformation in electro cardiology is relatively new field of research, many methodological aspects (Choice of the mother wavelet, values of the scale parameters) of the wavelet technique will require further investigations in order to improve the clinical usefulness of this novel signal processing system. Concurrently diagnostic and prognostic significance of wavelet techniques in various fields of electro cardiology needs to be established in large clinical studies. Most existing algorithms have shown QRS detection by this achieves 93.3% accuracy. However, if ECG signals

measurement systems are used in energy expenditure areas, reliable and efficient algorithms in QRS detection are so important. Very simple and fast reliable methods are proposed in this paper. This technique is very easy to perform and it does not need any complex mathematical calculations such as Fourier methods, cross-correlation.

## References

- [1] L. Sornmo and P. Laguna, "electrocardiogram (ecg) signal processing".
- [2] J. Pan and W. J. Tompkins, "A real-time QRS detection algorithm", *IEEE Trans. Biomed. Eng.*, vol.32, (1985), pp.230–236.
- [3] V. X. Afonso, W. J. Tompkins, T. Q. Nguyen and S. Luo, "ECG beat detection using filter banks", *IEEE Trans. Biomed. Eng.*, vol.46, (1999), pp.192–202.
- [4] M. Bahoura, M. Hassani, and M. Hubin, "DSP implementation of wavelet transform for real time ECG wave forms detection and heart rate analysis", *Comput. Methods Programs Biomed*, vol.52, no.1, (1997), pp.35–44.
- [5] Y. H. Hu, W. J. Tompkins, J. L. Urrusti and V. X. Afonso, "Applications of artificial neural networks for ECG signal detection and classification", *J. Electrocardiology*, vol.26, (1993), pp. 66-73.
- [6] <http://www.physionet.org/physiobank/database/mitdb/>.
- [7] R. Ganguli, "Noise and Outlier Removal from Jet Engine Health Signals using Weighted FIR Median Hybrid Filters", *Mechanical Systems and Signal Processing*, vol.16, no.6 , (2002), pp.967-978.
- [8] C. Li, C. Zheng, *Proc. Annual Int. Conf. IEE Eng. in Med. & Biol. Soc.*, (1993); San Diego, California.
- [9] Neural Network Toolbox. Available: <http://www.mathworks.com>.
- [10] L. Khadra, A. Fraiwan and W. Shahab, "Neural-wavelet analysis of cardiac arrhythmias", *Proceedings of the WSEAS International Conference on Neural Network and Applications (NNA '02)*, (2002); Interlaken, Switzerland.
- [11] S. Pachekhiya and A. K. Wadhvani, "Disease Diagnosis Of Heart Muscles Using Error Back Propagation Neural Network", *International Journal of Engineering Science and Technology*.