

# **An Efficient Signal Analysis Method for Detection and Classification of ECG Noises for Wearable ECG Monitoring Devices**

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**ABSTRACT:** An assessment of electrocardiogram (ECG) signal quality is an unavoidable first step in most holter and ambulatory ECG signal analysis. In this paper, we present a simple method for automatically detection and classification of ECG noises. It is a tool that measures and records the electrical activity of the heart. Interpretation of these details allows diagnosis of a wide range of heart conditions. The electrocardiogram (ECG) is a time-varying signal reflecting the ionic current flow that causes the cardiac fibres to contract and subsequently relax. The surface ECG is obtained by recording the potential difference between two electrodes placed on the surface. This constructs an automatic detection and classification of ECG noises. Experimental results show that the method achieves acceptable classification accuracy on different types of clean and noisy ECG signals.

**KEYWORDS:** Holter and ambulatory, Electrocardiogram, Diagnostic tool, Signal reflecting, Cardiac fibres

## **I. INTRODUCTION**

The electrocardiogram (ECG) is the recording of the heart's electrical potential versus time. Three types of predominant noise that commonly contaminate the signal are baseline wander (BW) noise, electromyographic (EMG) interference, and 50 or 60 Hz power line interference. Among them power line interference is a significant source of noise. Cables carrying ECG signals from the patients to the monitoring equipment are susceptible to electromagnetic interference (EMI) from the 50/60Hz power line noise. Many methods were proposed in the past for the removal of power line interference in the ECG. They can be categorized into non-adaptive and adaptive filtering. The non-adaptive filtering approach employs a sharp notch filter and is easy to implement at low cost. However its performance depends on the frequency stability of the power line.

Adaptive filtering, on the other hand, is able to effectively remove time-varying power line frequency, but requires considerable computational power which is not suitable for portable battery powered ECG devices. To lower power consumption we opt for non-adaptive filtering based upon a FIR filter with a linear phase property to obtain the noise reduction without introducing the phase distortion. The main advantage of using an FIR filter is that it minimizes waveform distortion. In our design, we use the notch filter with a pole/zero cancelling method, the comb notch filter with a pole/zero cancelling method and the equiripple notch filter with the usage of Parks-McClellan algorithm. By the comparison of the transition bandwidth, stop band attenuation ( $A_{stop}$ ) of these filters, we can learn the frequency response of these filters. Furthermore we use the mean square error (M.S.E.) to estimate the embedded 50/60 Hz noise. We compute the M.S.E. with respect to the order,  $N$ , these filters and plot a response between M.S.E. and  $N$ . The results show that the proposed filter effectively removes the power line noise from the ECG signal.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 7, July 2018

Electrocardiogram (ECG or EKG) is a diagnostic tool that measures and records the electrical activity of the heart in exquisite detail. Interpretation of these details allows diagnosis of a wide range of heart conditions. These conditions can vary from minor to life threatening. An ECG is generated by a nerve impulse stimulus to a heart. The current is diffused around the surface of the body surface. The current at the body surface will build on the voltage drop, which is a couple of  $\mu\text{V}$  to mV with an impulse variation. Usually, this is very small amplitude of impulse, which requires a couple of thousand times of amplification.

A typical ECG tracing of a normal heartbeat (or cardiac cycle) consists of a P wave, a QRS complex and a T wave. A small U wave is normally visible in 50 to 75% of ECGs. The baseline voltage of the electrocardiogram is known as the isoelectric line. Typically the isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave. The electrical activity of the heart can be recorded at the surface of the body using an electrocardiogram. Therefore the electro-cardio-gram (ECG) is simply a voltmeter that uses up to 12 different leads (electrodes) placed on designated areas of the body. Figure 1 shows the typical ECG trace. The electrical activity of the heart is generally sensed by monitoring electrodes placed on the skin surface. The electrical signal is very small (normally 0.0001 to 0.003 volt). These signals are within the frequency range of 0.05 to 100 Hertz (Hz.) or cycles per second.

Unfortunately, other artifactual signals of similar frequency and often larger amplitude reach the skin surface and mix with the ECG signals. Artifactual signals arise from several internal and external sources. Means Electro-cardio-graphic signals (ECG) may be corrupted by various kinds of noise. The ECG is a voltage difference, recorded between two metal plates or electrodes on the surface of the body, usually on two limbs. Different pairs of electrodes are used to record signals described as "Lead I", "Lead II" and "Lead III". For example, Lead I records the voltage at the Left Arm minus the voltage at the Right Arm.

## II. RELATED WORK

### EXISTING SYSTEM

In existing an improvement of the measurement evaluation method is introduced, which is used during the sport activity in real-time. Health monitoring systems and sport activity risk calculation proved to be very advantages to avoid emergency situations. Using these kinds of applications the necessary alarm signals can be sent in time. In this way, lesions, health impairments, and mortality can be reduced and the patient outcomes can be improved. Due to the uncertainty, imprecision, and subjectivity of the data and evaluation processes of medical applications, fuzzy approach can be a useful tool to increase the reliability of the decisions.

### METHODOLOGIES OF EXISTING SYSTEM

**DCT:** The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. DCT and Fourier transforms convert images from Spatial-domain to frequency-domain to de-correlate pixels. DCT breaks an image into  $8 \times 8$  units and each pixel is scanned and the transform is applied. Zig Zag scan method is used here.

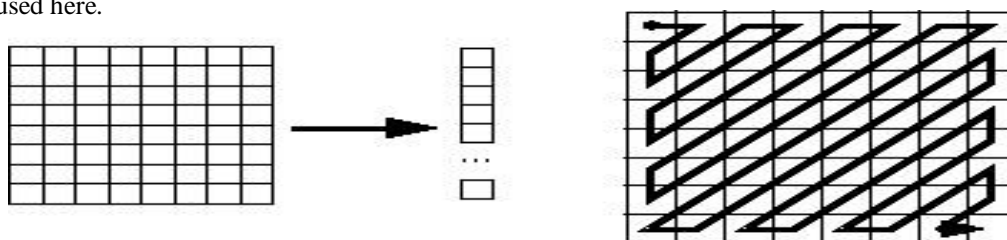


Fig.1: Zig Zag Scan Structure

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## FREQUENCY DISTORTION IN DCT:

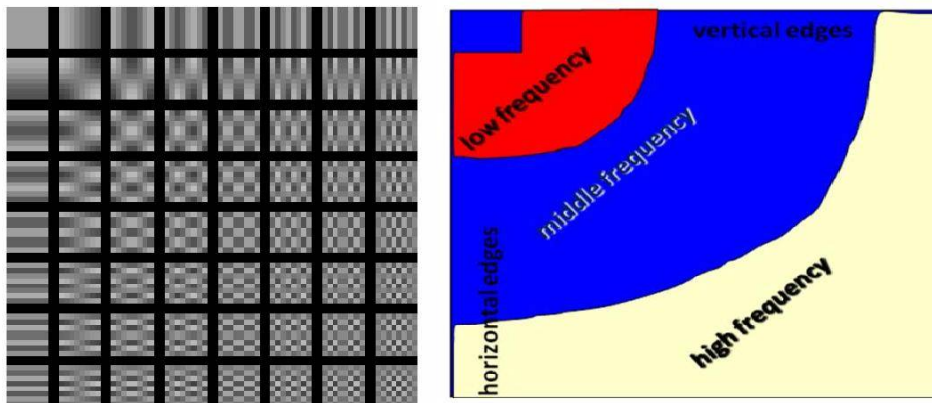


Fig.2: Frequency distortion in DCT

## PROPOSED SYSTEM

**FUNCTIONS OF PROPOSED SYSTEM:** The proposed detection and classification method is tested and validated using a wide variety of clean and noisy ECG signals. Results show that the method can achieve an average sensitivity (Se) of 97.88%, positive productivity (+P) of 91.18% and accuracy of 89.06%. Unlike other existing methods, the proposed method uses simple filtering, feature extraction and classification techniques. The proposed method consists of four major steps: UWT, Encryption, Denoising, and Inverse UWT. In the proposed method, the features including the global and local dynamic amplitude ranges and autocorrelation maximum peak extracted for detection and classification of ECG noises. In proposed a simple straightforward method for automatically detection and classification of ECG noises.

**UWT:** UWT – Undecimated Wavelet Transform and it is nothing but Stationary wavelet transform . The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input – so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients.

**STEPS IN UWT:** Apply high and low pass filters to the data at each level and do not decimate(don't select only odd indices). Modify the filters at each level, by padding them with zeroes and computationally more complex.

## SYSTEM REQUIREMENTS

### HARDWARE SYSTEM CONFIGURATION

- Pentium(R) D CPU 3GHZ
- 1 GB of RAM
- 500 GB of Hard disk

### SOFTWARE SYSTEM CONFIGURATION

- MATLAB 7.5 and above versions
- Neural network Toolbox

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- .Net Framework 4.0
- C# Language
- SQL Server 2008

## SOFTWARE DESCRIPTION

### MATLAB:

MATLAB is an array language, initially popular for rapid prototyping, but is now being increasingly used to develop production code for numerical and scientific applications. Typical MATLAB programs have abundant data parallelism. These programs also have control flow dominated scalar regions that have an impact on the program's execution time. Today's computer systems have tremendous computing power in the form of traditional CPU cores and also throughput-oriented accelerators such as graphics processing units (GPUs). Thus, an approach that maps the control flow dominated regions of a MATLAB program to the CPU and the data parallel regions to the GPU can significantly improve program performance.

The name 'Matlab' comes from two words: matrix and laboratory. According to The MathWorks (producer of Matlab), Matlab is a technical computing language used mostly for high-performance numeric calculations and visualization. It integrates computing, programming, signal processing and graphics in easy to use environment, in which problems and solutions can be expressed with mathematical notation. Basic data element is an array, which allows for computing difficult mathematical formulas, which can be found mostly in linear algebra. But Matlab is not only about math problems. It can be widely used to analyze data, modeling, simulation and statistics. Matlab high-level programming language finds implementation in other fields of science like biology, chemistry, economics, medicine and many more.

### Starting MATLAB

After logging into your account, you can enter MATLAB by double-clicking on the MATLAB shortcut icon (MATLAB 7.0.4) on your Windows desktop. When you start MATLAB, a special window called the MATLAB desktop appears. The desktop is a window that contains other windows.

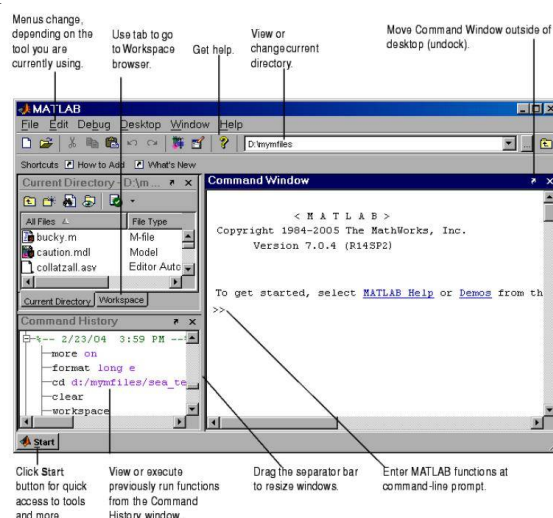


Fig.3: MATLAB command Window



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## DESIGN AND IMPLEMENTATION MODULES

- ECG Preprocessing
- Noise Reduction
- Secure Data Transmission
- UWT
- \Neural Network Classifier
- MLP

## MODULES DESCRIPTION

The proposed method is to study and analyse Electrocardiograph (ECG) waveform to detect abnormalities present with reference to P, Q, R and S peaks. The first phase includes the acquisition of real time ECG data and generation of signals followed by pre-processing. In the next phase, ECG image compression and decompression using RSA key. Thirdly, the procured ECG signal is subjected to feature extraction and noise reduction takes place. The extracted features detect abnormal peaks present in the waveform. Thus the normal and abnormal ECG signal could be differentiated based on the features extracted. The work is implemented in the most familiar multipurpose tool, MATLAB. This software efficiently uses algorithms and techniques for detection of any abnormalities present in the ECG signal. Proper utilization of MATLAB functions (both built-in and user defined) can lead us to work with ECG signals for processing and analysis in real time applications. The simulation would help in improving the accuracy and the hardware could be built conveniently.

## ECG PREPROCESSING

The electrical activity of the heart is generally sensed by monitoring electrodes placed on the skin surface. The electrical signal is very small (0.0001 to 0.003). These signals are within frequency range of 0.05 to 100Hz (Hertz) or cycle per second. In ECG signal processing, instrumentation amplifier plays major role since signal generated by human body are very low in amplitude. High gain must be obtained with high common-mode rejection ratio (CMRR). ECG signals are very noisy, usually 50Hz. MATLAB was used to test and adjust a digital filter as referred from [1], in order to obtain a good QRS complex noise free, which represents the ventricular depolarization in the ECGs, i.e., it shows the electrical impulse of the heart as it passes through the ventricles.

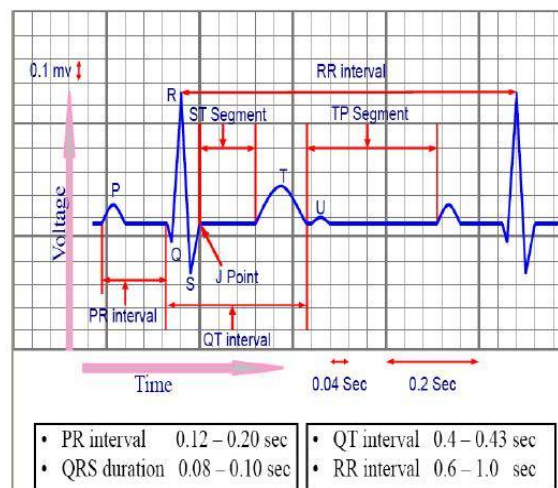


Fig.4: Typical one-cycle ECG signal tracking

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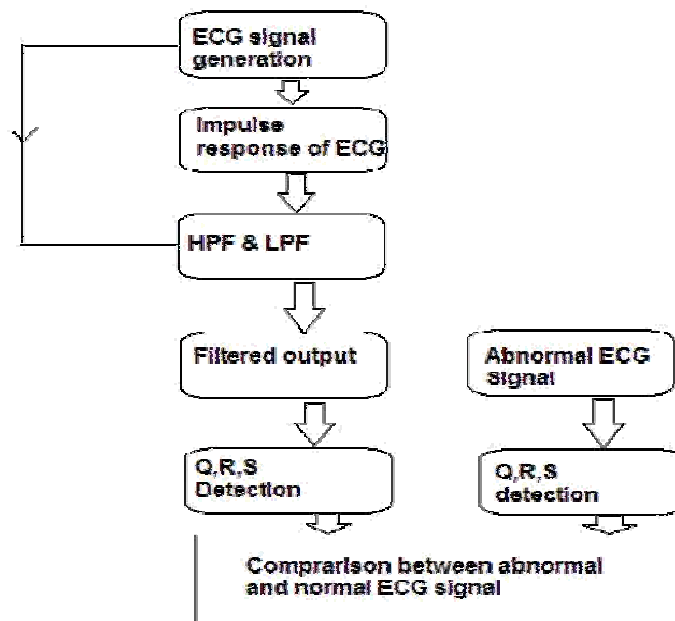


Fig: 5 Comparison of Normal and Abnormal ECG Signal

The ECG signal is generated by the MATLAB code from real time data. The objective is to produce the typical ECG waveforms of different leads and as many arrhythmias as possible. This technique has many advantages in the simulation of ECG waveforms. Firstly saving time, secondly removing noise and thirdly Q,R,S detection in an easy manner.

## ECG Q,R,S Detection

A typical scalar cardiogram lead is shown the significant features of waveform are the P, Q, R, S waves, the duration of each wave and time intervals such as P-R, S-T and Q-T intervals. ECG signal is periodic with fundamental frequency determined by the heartbeat. It also satisfies the Dirichlet's condition. Hence, Fourier series can be used to represent an ECG signal. If we observe Fig. 1 carefully, we may notice that a single period of an ECG signal is a mixture of triangular and sinusoidal waveforms. The significant feature of ECG signal can be represented by shifted and scaled versions. Such one waveform is shown in Figure QRS, Q and S portion of ECG signal can be represented by triangular waveforms. OP, T and U portions can be represented by triangular waveforms.

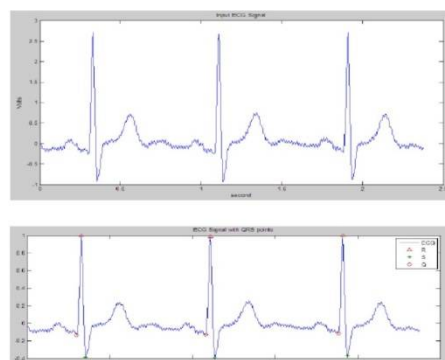


Fig.6: Typical ECG and Peak waveform in MATLAB

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The detection of the R-peaks and consequently of the QRS complexes in an ECG signal provides information about the heart rate and the conduction velocity. It also bears the information about the condition of tissue within the heart as well as various abnormalities. It supplies the evidence for the diagnosis of cardiac disease. For this reason, it has drawn considerable attention in the ECG signal-processing field. However, the presence of the noise and time-varying morphology makes the detection difficult. Fig. shows the peak/valley detection from original ECG signal. The peaks and valleys (especially Q, R and S points) become more distinct after this analysis. After extracting the feature of QRS complex detection, we can analyze the feature with others methods. For example, we can perform heart rate variability (HRV) analysis on the R-R interval signal to demonstrate the state of the heart and the nerve system.

## QRS Detection Method

Pan-Tompkins algorithm is the mostly used for QRS wave detection. Three graphical deflections perceived on a usual electrocardiogram (ECG) is combined and given the term QRS wave. The QRS wave is the dominant and apparent portion of the deflections traced. It is the depolarization of the right and left ventricles of the human heart. In adults, it usually persists 0.06 - 0.10 s, in children and during physical activity it is short. To reduce the noise, the wave is send through a band pass filter poised of cascaded high-pass and low-pass integer filters. Following processes are Derivative Filter differentiation, squaring, and moving integration of the signal.

## Pan Tompkins Algorithm

### Band Pass Filter

The band pass filter is designed by connecting low pass filter and high pass filter in cascade. The low pass filter is used in the circuit to suppress the high frequency noise. Speed is high since floating point processing is not required. The merits of designed band pass filter for the QRS detection algorithm is that it diminishes the ECG signal noise by matching the spectrum of average QRS complex, eliminates the noise owing to muscle artifacts. It also includes wandering of baseline and elimination of T wave interference. The pass band range includes around 5 to 15 Hz range due to which the energy of QRS is maximized. The filter is an integer filter



Fig. 7 Block Diagram of QRS Detection

The second order low pass filter has the transfer function of as shown in equation (1).

$$H(z) = (1 - z^{-6})^2 / (1 - z^{-1})^2 \dots\dots\dots (1)$$

The cut- off frequency of the filter is 11 Hz, delay is 5 samples and the gain is 36 [9]. The difference equation of the filter is as shown in equation.

$$y(nT) = 2y(nT-T) - y(nT-2T) + x(nT) - 2x(nT-6T) + x(nT-12T) \dots\dots\dots (2)$$

The high pass filter is implemented by subtracting a first order low pass filter from an all pass filter with delay . The transfer function of the low pass filter is as shown in equation

$$H_{low}(z) = Y(z)/X(z) = (1 - z^{-32}) / (1 - z^{-1}) \dots\dots\dots (3)$$

The transfer function of the high pass filter is as shown in equation

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$$H(hp)(z)=P(z)/X(z)=z^{-16}[(1-z^{-32})/(1-z^{-1})] \dots\dots\dots (4)$$

The low cut off frequency of the filter is about 5 Hz and delay is 80 ms.

## Derivative Filter

The signal received from the band pass filter is differentiated to get the data about the slope of the QRS wave. A five point derivative is applied with the transfer function. the signal established the differentiation operation in frequency domain. We also have derived the expression in the frequency domain for the operation of integration. This is because if we accomplish the derivative operation by multiplying by  $i2\pi f$ , then to undo the derivative (integrate) all we have to do is divide by  $i2\pi f$ . That is, the frequency domain expression for the indefinite integral  $s(t) dt$  is simply  $1/(i2\pi f) \times S(f)$ . The transfer function for integration in the frequency domain is  $1/(i2\pi f)$ .

## ECG FEATURE EXTRACTION AND NOISE REDUCTION

Generally, the recorded signal is often contaminated by noise and artifacts that can be within the frequency band of interest and manifest with similar characteristic as the ECG signal itself. In order to extract noisy ECG signals, we need to process the basic ECG signal. ECG signal processing can be roughly divided in to two stages, Preprocessing and Feature extraction. The preprocessing stage removes or suppresses noise from the raw ECG signal. The feature extraction stage extracts diagnostic information from the ECG signal referred as from Preprocessing ECG signals help us remove contaminants from ECG signals.

ECG contaminants can be classified into the following categories referred as from:

- Power line interference
- Electrode pop or contact noise
- Patient-electrode motion artifacts
- Electromyographic (EMG) noise
- Baseline wandering

Among these noise, the power line interference and the baseline wandering are the most significant and they can strongly affect ECG signal analysis. Except for these two noises, other noises may be wideband and usually complex stochastic process which also distort the ECG signal. The power line interference is narrow-band noise centered at 60 Hz (or 50 Hz) with a bandwidth of equal or less than 1 Hz. Usually the ECG signal acquisition hardware can remove the power line interference. However, the baseline wandering and other wideband noises are not easy to be suppressed by hardware equipments. Instead, the software scheme is more powerful and feasible for offline ECG signal processing. We can use the following MATLAB code method to remove the noise represent the filtered output of noisy ECG signal.

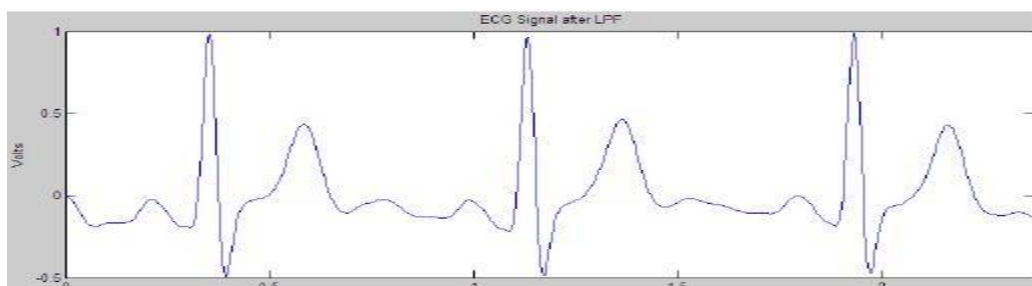


Fig.8: Typical filtered output of noisy ECG signal

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## SECURE DATA TRANSMISSION OF BIOMEDICAL SIGNALS

Telemedicine system using communication and information technology to deliver biomedical signals for long-distance medical services has become reality. In either the urgent treatment or ordinary health care, it is necessary to compress the signals for the efficient use of bandwidth. In addition, when compressed biomedical signals or data are delivered over a public channel such as the Internet, their privacy and security would also be an important issue. The excellent biomedical signal compression method, and the AES (advanced encryption standard) is the state-of-the-art data encryption standard. Data compression and encryption are normally treated as two separate and independent research areas or building blocks in a communication system. However, they are jointly considered in this paper, where we propose a partially encrypting scheme combining AES. Then AES is used to encrypt only the important part that can be defined and chosen by a user. The proposed scheme has, therefore, the advantage of encryption scalability. The experiments on electrocardiogram signals and medical images show that the proposed scheme can have significant security protection even only a small portion of compressed data is encrypted, resulting in the considerable saving of processing time.

The widespread use of computers and the continuous development of communication networks, computers and communication networks are natural mediums for many forms of data exchange in various applications. Generally, we often have a public communication network, where the illegal access of data is always a potential threat. Hence, a lot of network security techniques, including encryption, digital signature and authentication, are proposed. Information security has always been an extremely important issue for national defense, finance, multi-media and medical data. Considering the software and hardware cost, it is still a tough challenge to design a simple and highly effective encryption algorithm. By convention, data compression and encryption are two separate research areas. Furthermore, compression (source coding) and encryption are two separate and independent coding blocks in a communication system. However, related algorithms have been proposed based on the joint consideration of compression and encryption.

### ECG Key GEN Using RSA Encryption Technique

Efficient technique by ECG signal to generate key from the peak value of QSR ECG value by the RSA Encryption algorithm. The key generator using electrocardiogram (ECG) signals comprises two independent stages, namely, enrollment and verification-generation. This work is based on the uniqueness and quasi-stationary behavior of ECG signals with respect to an individual. RSA implements a public-key crypto system, as well as digital signatures. Then the original data decrypted by the same technique with low SNR margin and Bit Error Rate (BER).

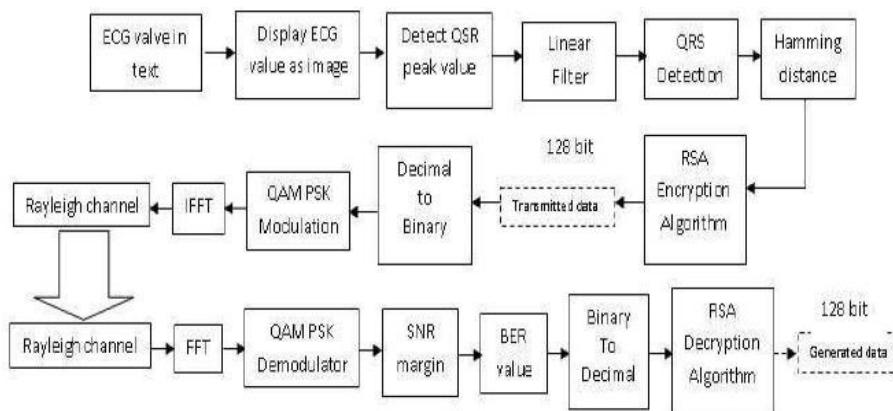


Fig. 9: RSA Process



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## RSA Algorithm

To avoid the reputed complexity of factoring large integers the factoring problem, RSA an algorithm for public-key cryptography was described. RSA is for Ron Rivest, Adi Shamir and Leonard Adleman, who took the initiation to describe the algorithm in 1977. Also an English mathematician, Clifford Cocks have described a corresponding structure in 1973, however it wasn't declassified until 1997. In RSA the product of two large prime numbers is created and then published with a supplementary value, as their public key. The secrecy of prime factors is maintained. The public key can be used to encrypt a message. However with presently available structure, if the public key is very huge, only somebody aware of the prime factors can possibly decode the information. RSA comprises of public key and a private key. The public key is well-known by everybody and is utilised for encrypting information. By means of the private key, the information encrypted with the public key can be decrypted in a sensible quantity of time. The subsequent ways are followed for generating the keys for the RSA algorithm.

## Encryption

Aabha communicates the public key (m, f) to Ali and maintains the private key secret. Later Ali desires to mail message M to Aabha. Ali initially converts M into an integer m, such that  $0 \leq m < n$  by by means of an agreed-upon reversible protocol recognized as a padding scheme. Ali next calculates the cipher text c equivalent to The above process is made rapidly by the technique of exponentiation by squaring. Ali then transmits c to Aabha. The encryption process run by separate function as "rsaen.m" file. The equation is in the matlab form of

$$c = m.^e * (\text{mod}(3, n));$$

## Decryption

Aabha can recuperate m from c by by means of the private key d via computing Given m, the original message M can be recovered by reversing the padding scheme. The encryption presses run by separate function the equation is in the matlab form of  $\text{Msg} = [c1'.^{\text{key}(2)} / (\text{mod}(3, \text{key}(1))];$

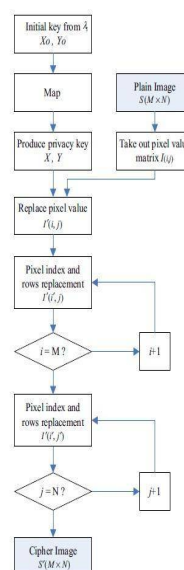


Fig.10: RSA Algorithm Flow Chart

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## UWT

UWT algorithm designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT). The earlier method of ECG signal analysis was based on time domain method. But this is not always sufficient to study all the features of ECG signals. So, the frequency representation of a signal is required.

## NEURAL NETWORK BASED CLASSIFICATION FOR ECG SIGNALS

Cardiac Arrhythmia represents heart abnormalities. This problem is faced by people, irrespective of age. Even the physicians feel difficulty in diagnosing the abnormal behavior of heart accurately. Accurate detection of cardiac abnormalities helps to provide right treatment. Classification plays an important role in predicting abnormal behaviors of heart and it helps the physician to treat the patients who are having cardiac arrhythmia. Extracted features from ECG (Electrocardiogram) signals are used for classification. It is possible to extract multiple features from ECG signal regardless of the features used for classification. Classification performed using all the extracted features leads to misclassification of abnormalities. So feature selection is an important concept in classifying the normal and abnormal behavior of heart. MIT BIH Arrhythmia dataset is used in our proposed work where the classification is done in MATLAB using Fitting Neural Network.

## Classifier Evaluation Metrics

Fitting neural network Classifier is applied on this MIT BIH Arrhythmia dataset. Their results are analyzed and used to determine the accuracy of classifier. There are various evaluation metrics which determines the accuracy of classifier. Accuracy is measured on test sets which denotes the percentage of test set tuples that were correctly classified by the classifier. Error rate or Misclassification rate of a classifier C can be determined as  $1 - \text{Acc}(C)$ , where  $\text{Acc}(C)$  is the accuracy of classifier C. Confusion matrix which is a tool for analyzing how well classifier can recognize tuples of different classes.

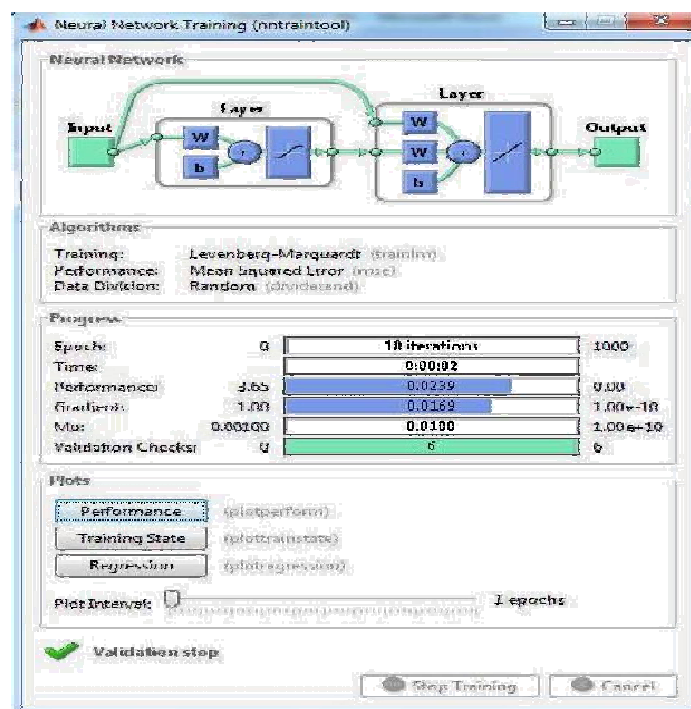


Fig.11: Neural Network Tool

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## MLP

The Artificial Neural Networks (ANN) are the tools, which can be used to model human cognition or neural biology using mathematical operations. An ANN is a processing element. It has certain performance characteristics in common with biological neural networks. A neural network is characterized by 1) its pattern of connections between the neurons (called its architecture), 2) its algorithm of determining the weights on the connections (called its training, or learning algorithm), and 3) its activation function. The MultiLayer Perceptron (MLP) is the most common neural network.

This type of neural network is known as a supervised network because it requires a desired output in order to learn. The purpose of the MLP is to develop a model that correctly maps the input data to the output using historical data so that the model can then be used to produce the output result when the desired output is unknown.

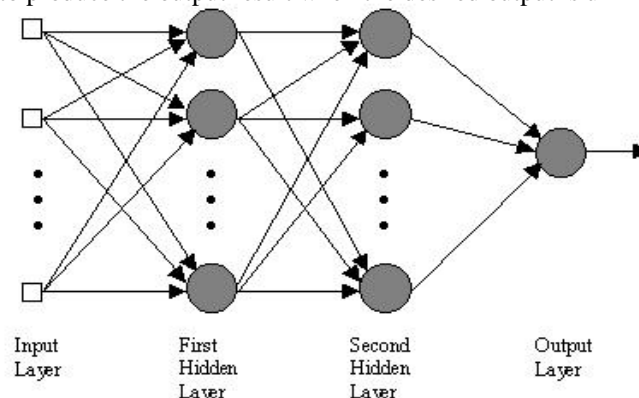


Fig. 12: MLP architecture with two hidden layer

## MultiLayer Perceptron (MLP) Learning Algorithm

### Back-Propagation Algorithm

In the first step, the MLP is used to learn the behaviour 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 compares the result that is obtained in this step with the result that was expected. 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 closer and closer to produce the desired output.

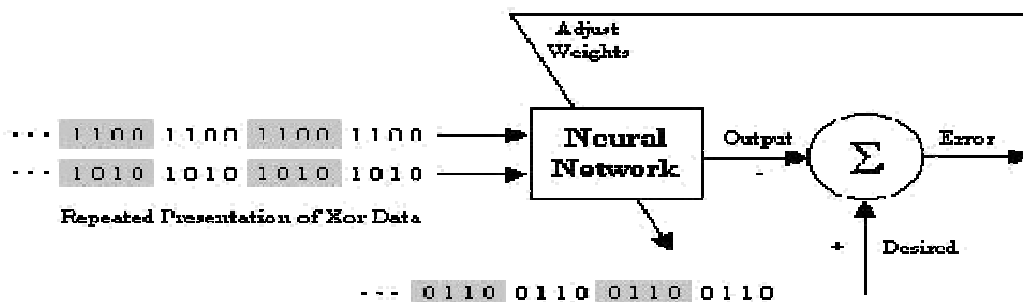


Fig. 13: Neural network learning algorithm

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There are different training algorithms, while it is very difficult to know which training algorithm is the fastest for a given problem. In order to determine the fastest training algorithm, many parameters should be considered. For instance, the complexity of the problem, the number of data points in the training set, the number of weights, and biases in the network, the and error goal should be evaluated. The proposed MLP neural networks were trained using 90 training vectors from 10 files of the MIT-BIH arrhythmia database. The trained MLP NNs were tested using 45 patterns (15 testing patterns for each class) using 10 files including normal and two arrhythmias. In order to test the performance of the trained MLP NN, We have used two criteria to compare the trained networks, recognition samples and recognition rate. Recognition rate is defined as follows:

$$A=100x(Nc/Nt).$$

Where A is the recognition rate, Nc is the number of correctly classified patterns, and Nt represents the total number of patterns.

Normal: 103-115-121-123

PB: 104-107-217

APB: 209-220-223.

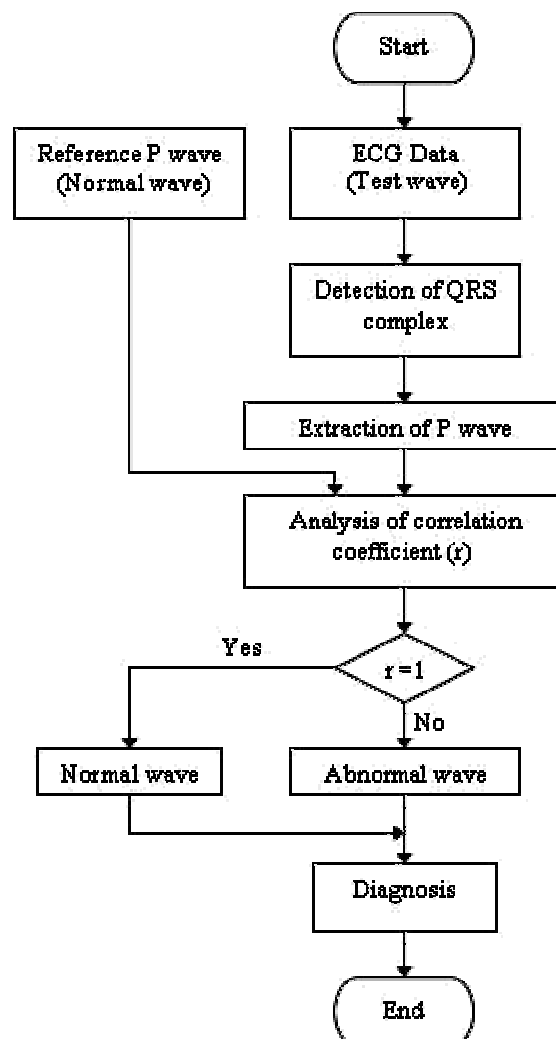


Fig. 14: MLP Learning Algorithm Flow Chart

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*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

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Vol. 7, Issue 7, July 2018

If the learning rate is set too high, the algorithm can oscillate and it became unstable, while if the learning rate is too small, the algorithm takes too long to converge. It is hard to determine and obtain the optimal setting for this variable before training phase. This is because during the training process, the optimal learning rate is changed.

## III. CONCLUSION

In this project, conceive of a smart ECG measurement scheme founded on web-service-oriented architecture for heart rank monitoring of cardiac patients has been suggested. The apparatus records and analyses the ECG signal of the persevering to make a dependable diagnosis, and in case of emergency, it communicates the persevering facts and figures to a remote station for aid. In this case, the system connects to the Web crisis Service, which verifies the patient facts and figures retained in a facts and figures base and calls the crisis service.

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