QRS Wave Detection Using Multiresolution Analysis

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S.Karpagachelvi[1] Dr.M.Arthanari, Prof. & Head[2] M.Sivakumar[3]

Abstract-Te electrocardiogram (ECG or EKG) is basically a diagnostic tool that measures and records the electrical signal by comparing the activity of heart. It is most commonly used to perform cardiac test, since it acts as screening tool for cardiac abnormalities. This is necessary because no single point provides a complete picture of what is going on in the heart. It mainly comprises of PQRS&T wave by showing corresponding time and frequency. PQRST key feature detector is based on wavelet transform which robust to time varying and noise. It will analyze the waveform including noise purification, sample design of digital ECG. R peak is mainly used for detection. In this work, we have developed an electrocardiogram (ECG) feature extraction system based on the multi-resolution wavelet transform. It mainly includes two stages. In the first stage, algorithm is quoted by using discrete wavelet transform for de-noise the signal. In second step multiresolution is done for QRS complex detection. The proposed schemes were mostly based on Fuzzy Logic Methods, Artificial Neural Networks (ANN), Genetic Algorithm (GA), Support Vector Machines (SVM), and other Signal Analysis techniques.

Keywords-Cardiac Cycle, ECG signal, P-QRS-T waves, Feature Extraction, Haar wavelets.

I. INTRODUCTION

The investigation of the ECG has been extensively used for diagnosing many cardiac diseases. The ECG is a realistic record of the direction and magnitude of the electrical commotion that is generated by depolarization and re-polarization of the atria and ventricles. One cardiac cycle in an ECG signal consists of the P-QRS-T waves. Figure 1 shows a sample ECG signal. The majority of the clinically useful information in the ECG is originated in the intervals and amplitudes defined by its features (characteristic wave peaks and time durations). The improvement of precise and rapid methods for automatic ECG feature extraction is of chief importance, particularly for the examination of long recordings [1].

The ECG feature extraction system provides fundamental features (amplitudes and intervals) to be used in subsequent automatic analysis. In recent times, a number of techniques have been proposed to detect these features [2] [3] [4]. The previously proposed method of ECG signal analysis was

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About-[1]*Doctoral Research Scholar, Mother Teresa Women's University, Kodaikanal, Tamilnadu, India.(email;karpagachelvis@yahoo.com)*
About-[2]*Dept. of Computer Science and Engineering,Tejaa Shakthi Institute of Technology for Women Coimbatore- 641 659, Tamilnadu, India (email: arthanarimsvc@gmail.com)*
About-3 *Doctoral Research Scholar Anna University – Coimbatore Tamilnadu, India(email;sivala@gmail.com)*

based on time domain method. But this is not always adequate to study all the features of ECG signals. Therefore the frequency representation of a signal is required. The deviations in the normal electrical patterns indicate various cardiac disorders. Cardiac cells, in the normal state are electrically polarized [5].

ECG is essentially responsible for patient monitoring and diagnosis. The extracted feature from the ECG signal plays a vital in diagnosing the cardiac disease. The development of accurate and quick methods for automatic ECG feature extraction is of major importance. Therefore it is necessary that the feature extraction system performs accurately. The purpose of feature extraction is to find as few properties as possible within ECG signal that would allow successful abnormality detection and efficient prognosis.
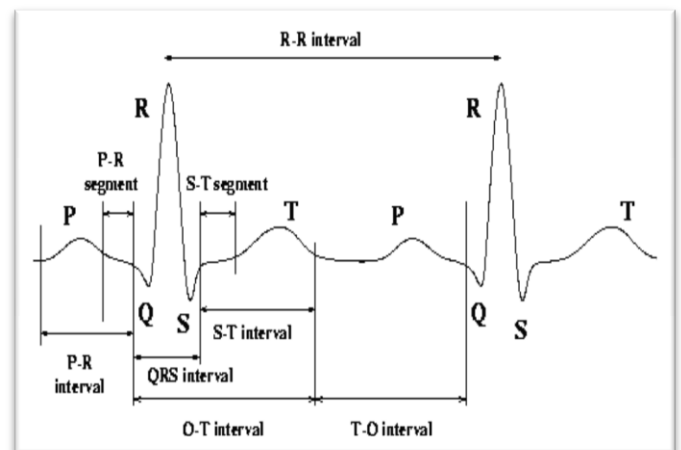

Figure.1 A Sample ECG Signal showing P-QRS-T Wave

recent year, several research and algorithm have been developed for the exertion of analyzing and classifying the ECG signal. The classifying method which have been proposed during the last decade and under evaluation includes digital signal analysis, Fuzzy Logic methods, Artificial Neural Network, Hidden Markov Model, Genetic Algorithm, Support Vector Machines, Self-Organizing Map, Bayesian and other method with each approach exhibiting its own advantages and disadvantages. In this work, we have developed an electrocardiogram (ECG) feature extraction system based on the multi-resolution wavelet transform using haar coefficients and also provide an over view on various techniques and transformations used for extracting the feature from ECG signal. This paper is structured as follows. Section 2 discusses the related work that was earlier proposed in literature for ECG feature extraction. Section 3

gives a description of the DWT based ECG feature detection algorithm and Section 4 concludes the paper with fewer discussions

II.   RELATED WORK

ECG feature extraction has been studied from early time and lots of advanced techniques as well as transformations have been proposed for accurate and fast ECG feature extraction. This section of the paper discusses various techniques and transformations proposed earlier in literature for extracting feature from ECG.

A novel approach for ECG feature extraction was put forth by Castro et al. in [6]. Their proposed paper present an algorithm, based on the wavelet transform, for feature extraction from an electrocardiograph (ECG) signal and recognition of abnormal heartbeats. Since wavelet transforms can be localized both in the frequency and time domains. They developed a method for choosing an optimal mother wavelet from a set of orthogonal and bi-orthogonal wavelet filter bank by means of the best correlation with the ECG signal. The coefficients, approximations of the last scale level and the details of the all levels, are used for the ECG analyzed. They divided the coefficients of each cycle into three segments that are related to P-wave, QRS complex, and T-wave. The summation of the values from these segments provided the feature vectors of single cycles.

Mahmoodabadi et al. in [1] described an approach for ECG feature extraction which utilizes Daubechies Wavelets transform. They had developed and evaluated an electrocardiogram (ECG) feature extraction system based on the multi-resolution wavelet transform. The ECG signals from Modified Lead II (MLII) were chosen for processing. The wavelet filter with scaling function further intimately similar to the shape of the ECG signal achieved better detection. The foremost step of their approach was to de-noise the ECG signal by removing the equivalent wavelet coefficients at higher scales. Then, QRS complexes are detected and each one complex is used to trace the peaks of the individual waves, including onsets and offsets of the P and T waves which are present in one cardiac cycle.

A feature extraction method using Discrete Wavelet Transform (DWT) was proposed by Emran et al. in [7]. They used a discrete wavelet transform (DWT) to extract the relevant information from the ECG input data in order to perform the classification task. Their proposed work includes the following modules data acquisition, pre-processing beat detection, feature extraction and classification. In the feature extraction module the Wavelet Transform (DWT) is designed to address the problem of non-stationary ECG signals. It was derived from a single generating function called the mother wavelet by translation and dilation operations. Using DWT in feature extraction may lead to an optimal frequency resolution in all frequency ranges as it has a varying window size, broad at lower frequencies, and narrow at higher frequencies. The DWT characterization will deliver the stable features to the morphology variations of the ECG waveforms.

Tayel and Bouridy together in [8] put forth a technique for ECG image classification by extracting their feature using wavelet transformation and neural networks. Features are extracted from wavelet decomposition of the ECG images intensity. The obtained ECG features are then further processed using artificial neural networks. The features are: mean, median, maximum, minimum, range, standard deviation, variance, and mean absolute deviation. The introduced ANN was trained by the main features of the 63 ECG images of different diseases.

An algorithm was presented by Chouhan and Mehta in [9] for detection of QRS complexities. The recognition of QRS-complexes forms the origin for more or less all automated ECG analysis algorithms. The presented algorithm utilizes a modified definition of slope, of ECG signal, as the feature for detection of QRS. A succession of transformations of the filtered and baseline drift corrected ECG signal is used for mining of a new modified slope-feature. In the presented algorithm, filtering procedure based on moving averages [15] provides smooth spike-free ECG signal, which is appropriate for slope feature extraction. The foremost step is to extort slope feature from the filtered and drift corrected ECG signal, by processing and transforming it, in such a way that the extracted feature signal is significantly enhanced in QRS region and suppressed in non-QRS region.

Xu et al. in [10] described an algorithm using Slope Vector Waveform (SVW) for ECG QRS complex detection and RR interval evaluation. In their proposed method variable stage differentiation is used to achieve the desired slope vectors for feature extraction, and the non-linear amplification is used to get better of the signal-to-noise ratio. The method allows for a fast and accurate search of the R location, QRS complex duration, and RR interval and yields excellent ECG feature extraction results. In order to get QRS durations, the feature extraction rules are needed.

A modified combined wavelet transforms technique was developed by Saxena et al. in [11]. The technique has been developed to analyze multi lead electrocardiogram signals for cardiac disease diagnostics. Two wavelets have been used, i.e. a quadratic spline wavelet (QSWT) for QRS detection and the Daubechies six coefficient (DU6) wavelet for P and T detection. A procedure has been evolved using electrocardiogram parameters with a point scoring system for diagnosis of various cardiac diseases. The consistency and reliability of the identified and measured parameters were confirmed when both the diagnostic criteria gave the same results. Table 1 shows the comparison of different ECG signal feature extraction techniques.

Fatemian et al.[12] proposed an approach for ECG feature extraction. They suggested a new wavelet based framework for automatic analysis of single lead electrocardiogram (ECG) for application in human recognition. Their system utilized a robust preprocessing stage, which enables it to handle noise and outliers. This facilitates it to be directly applied on the raw ECG signal. In addition the proposed system is capable of managing ECGs regardless of the heart rate (HR) which renders making presumptions on the

individual's stress level unnecessary. The substantial reduction of the template gallery size decreases the storage requirements of the system appreciably. Additionally, the categorization process is speeded up by eliminating the need for dimensionality reduction techniques such as PCA or LDA. Their experimental results revealed the fact that the proposed technique out performed other conventional methods of ECG feature extraction.

III. DESCRIPTION OF ALGORITHM

A. Wavelet Selection

The large number of known wavelet families and functions provides a rich space in which to search for a wavelet which will very efficiently represent a signal of interest in a large variety of applications. Wavelet families include Biorthogonal, Coiflet, Harr, Symmlet, Daubechies wavelets, etc. There is no absolute way to choose a certain wavelet. The choice of the wavelet function depends on the application. The Haar wavelet algorithm has the advantage of being simple to compute and easy to understand. In the present work Haar wavelet is chosen. Savitzky Golay filtering is used to smooth the signal. To identify the onsets and offsets of the wave , the wave is made to zero base. To obtain the wavelet analysis, we used the Matlab program, which contains a very good "wavelet toolbox". First the considered signal was decomposed using Haar wavelet of the order of 1-5 has been evaluated. One of the key criteria of a good mother wavelet is its ability to fully reconstruct the signal from the wavelet decompositions. The fig 2 shows the decomposed signal. The high frequency components of the ECG signal decreases as lower details are removed from the original signal. As the lower details are removed, the signal becomes smoother and the noises disappears since noises are marked by high frequency components picked up along the ways of transmission. This is the contribution of the discrete wavelet transform where noise filtration is performed implicitly.

B. Peaks identification

In order to detect the peaks, specific details of the signal were selected. R peaks are the Largest amplitude points which are greater than threshold points are located in the wave. Those maxima points are stored and the R-R interval is determined. Their mean value is found which is used to find the portion of the single wave. A Q and S peak occurs about the R peak with in 0.1second. Calculating the distance from zero point or close zero left side of R peak within the threshold limit denotes Q peak. The onset is the beginning of the Q wave (or R-wave if the Q-wave is missing) and the offset is the ending of the S-wave (or R-wave if the S wave is missing). Normally, the onset of the QRS complex contains the high-frequency components, which are detected at finer scales. Calculating the distance from zero point or close zero right side of R peak within the threshold limit denotes Q peak.

C. Results

The algorithm presented in this section is applied directly at one run over the whole digitized ECG signal which are saved as data files provided by Physionet.
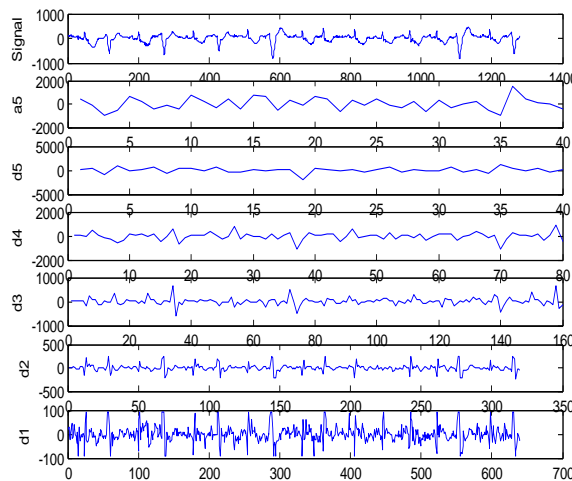QRS recognition is shown in Figure 3.

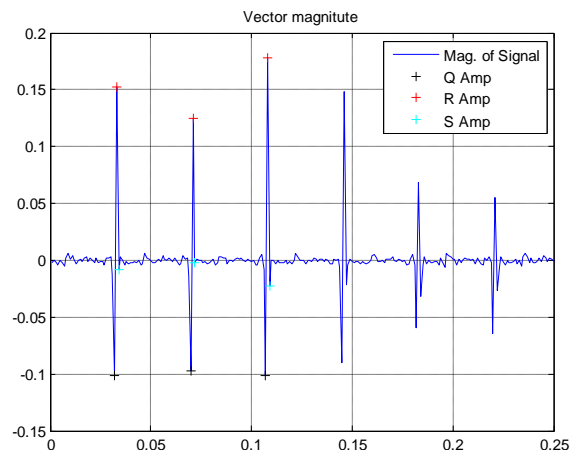Fig.2. Multiresolution decomposition of ECG signal from 801.dat file

Fig.3. Multiresolution process of wavelet-based peak Detection in 801.dat file

IV. CONCLUSION

In this paper, QRS key feature elements detection algorithm based on multi resolution analysis was proposed. The performance of the peak detection was examined by testing the algorithm on data standardized MIT-BIH database. The DWT based QRS detector performs well with standard techniques. Thus, the primary advantages of the DWT over existing techniques are noise removal and ability to process the time varying ECG data. In this work we pointed out the advantage of using wavelet transform associated with a threshold

strategy. Further, the possibility of detecting positions of QRS complexes in ECG signals is investigated and a simple detection algorithm is proposed. The main advantage of this kind of detection is less time consuming analysis for long

time ECG signal. The QRS detection in the ECG signal is explained with screen shots. The future work mainly concentrates on improving the proposed algorithm for various QRS waves of different patients. Moreover additional statistical data will be utilized for evaluating the performance of an algorithm in ECG signal feature detection. Improving the accuracy of diagnosing the cardiac disease at the earliest is necessary in the case of patient monitoring system. Therefore our future work also has an eye on improvement in diagnosing the cardiac disease.

V. References

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