# An Algorithm for ECG Analysis of Arrhythmia Detection

K.Amtul Salam[1]
Electronics and Communication Engineering Department
Bhoj Reddy Engineering College For Women
Hyderabad, Telengana, India.
salam.amtul@gmail.com

G.Srilakshmi[2]
Electronics and Communication Engineering Department
Bhoj Reddy Engineering College For Women
Hyderabad, Telengana, India.
srilaxmi524@yahoo.com

***Abstract*—During last few years, lot of study has provided on analysis and diagnosis of Electrocardiogram (ECG) signal. In this world, human is suffering from plenty of diseases. Arrhythmia is one of the diseases which cause by electrical malfunction in cardiac signal of heart. In arrhythmia condition victim loses consciousness and has no pulse which occur death within a minute, leads to sudden cardiac arrest. The P, QRS complex and T wave of ECG signal triggered and generates improper electrical signal that provide clinical information to diagnose. A new technologies and algorithms are introduced as a good approach towards detection and analysis of ECG. This paper aim at recognition of ST segment detection and QRS complex or R peak detection to diagnose arrhythmia. We propose novel method to detect arrhythmia from ECG signal using different concepts as Discrete Wavelet Transform (DWT), Adaptive Least Mean Square (ALMS) and Support Vector Machine (SVM).**

***Keywords— Electrocardiogram(ECG); Arrthymia; MIT-BIH database; QRS complex; ST segment.***

## I. INTRODUCTION

The world health organization estimation that 17.5 million represent 30% people died around global due to cardiovascular diseases. Among these 7.6 million due to coronary artery diseases (CAD)[3]. One of the most common causes of death in the world is arrhythmia. Cardiac arrhythmias are disturbances in the rhythm of the heart, manifested by irregularity or by abnormal fast rates or slow rates. Different reason to occur arrhythmia is not enough generation of rhythm in sinus node. Other is interruption in electrical signals of the heart causing ventricle to beat separately from the atria. In worst case, the ventricles are not able to beat effectively creating a condition called ventricular fibrillation. When this happen heart cannot pump blood and patient died quickly. The most common reason for sudden death is ventricular fibrillation. Patient with cardiac arrest over 30 years of age most frequently have coronary heart disease often involving three vessels, previous myocardial infarction and reduce ventricular function.

Electrocardiogram(ECG) remains the simplest non invasive and least expensive technology for diagnosis of arrhythmia. ECG is a continuous record of voltage changes that reflect the cyclic electro- physiologic events in myocardium. The task for signal processing is mainly the estimation of the clinically important parameters or features from ECG constituents which are complexes also interwave

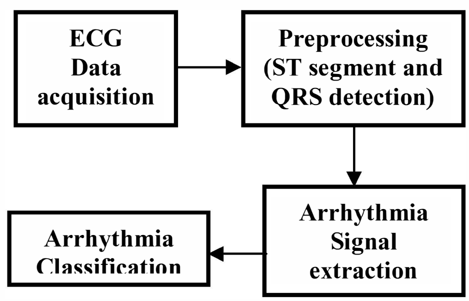


Fig.1. Block diagram of the Arrhythmia Detection System.

segments and cardiac intervals. There are there complex patterns that must be recognized as P complex, QRS complex and T complex. The parameters of complex that need to measured their peak amplitude and duration. However in the case of interwave segments and cardiac interval, only duration parameter is of interest. As ECG analyses provide information fragment of electrical instability to ventricular fibrillation. The damage cardiac tissues does not depolarize quickly. However, the most diagnostic parameter represents a state of unchanged polarization and abnormal ventricular rate. It begin at the offset of QRS depolarization duration with amplitude of R-peak and ends at onset of just before T-wave repolarization, indicate ST segment level from isoelectric line [3]as shown in Fig.2

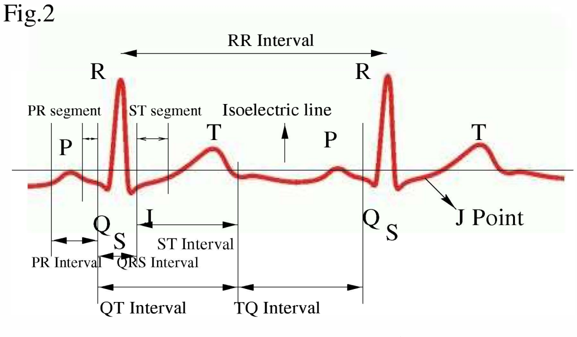


Fig.2 Sample two cycle ECG recording.

In this paper we focus on automated ST segment analysis and QRS detection of arrhythmia. Various techniques have been present to detect characteristic in ECG. Among existing our work carries discrete wavelet

978-1-4799-6085-9/15/$31.00 ©2015 IEEE

transform(DWT) for analyzing non stationary ECG signal, utilization of adaptive filter for feature extraction and to know approximate coefficient of ECG signal also support vector machine classifier is used as shown in Fig.1.

## II. Prior Work

A number of methods for arrhythmia detection have been proposed. Generally, almost of them are based on spectral estimation and signal point [3]. ECG analysis involved basically template matching technique. The idea behind this is to involve similarity between patterns which is related to the human cognitive process. Under this concept cross correlation, template subtraction for each point difference and automata based template matching for group difference with predetermined threshold level. Later several algorithms are based on differentiation form of QRS detection. Since the QRS complex is basically a high frequencies signal, differentiation of this morphology magnifies while attenuating the low frequency of the P and T waves. This principle is exploited simple digital system that detect the presence of QRS complex give estimation and analysis.

Recent methods have been applied to ECG used are fast fourier transform to analyze frequency component, fuzzy logic, neural network, genetic algorithm, support vector machine(SVM), wavelet transform and many more[5]. Author in [6] also proposed an algorithm for ST segment analysis using the multi resolution wavelet approach achieving accuracy of 97.3%. De chazal et al. classified the beat by analyzing the RR intervals and ECG morphology feature with heart beat segmentation [9]. The work presented in [10] uses a hybrid of fuzzy clustering and artificial neural networks to discriminate between different classes of beats. Our system performed with better accuracy by using discrete wavelet transformation as well as comparisons with classifier [11].

## III. Method and Material

Body surface ECG for one heart beat with its characteristic P, T wave and QRS complex is the time varying motion of cardiac vectors as describe in Fig.3. The cardiac spread of excitation represent by the vector at different point of time relates to the genesis of body surface ECG. Each wave of PQRST pattern represent a different information of signal. The slow moving depolarization of the atria which begin at sinoartrial(SA) node produce the P wave. The signal is delayed in the artioventricular (AV)node resulting in isoelectric region after the P wave, then as the purkinje system start delivering the stimulus to the ventricular muscle, the onset of the Q wave occurs. The rapid depolarization of ventricle muscle is depicted as large, fast moving vectors which begin producing the R wave. The maximal vector represents a point in time when most of the cells are depolarized, giving rise to the peak of the R wave. The final phase of ventricular depolarization occurs as the excitation spreads towards the base of the ventricle giving rise to the S wave.

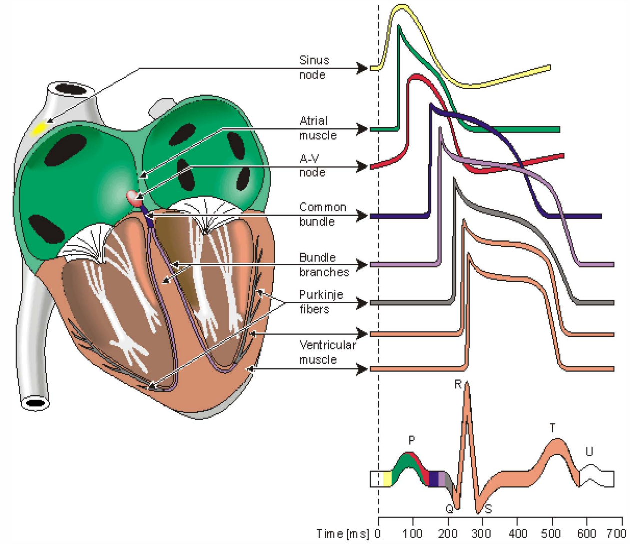


Fig.3 Representation electric activity from various regions of the heart. (CIBA Pharmaceutical Company, Division of CIBAGEIGY Corp. Reproduced, with permission, from The Ciba Collection of Medical Illustrations, by Frank H. Netter, M.D, 1969.)

### A. *ST Segment Detection*

The ST segment represents period of ECG just after depolarization, the QRS complex, and just before repolarization of the T wave. Change in the ST-Segment of ECG may indicate that there is deficiency in the blood supply to the heart muscle. Thus, it is important to be able to make measurements of ST-segment.

The analysis begins by detecting the QRS waveform. The R wave peak is then established by searching the interval corresponding before and after the QRS detection mark, for a point of maximal value. The Q wave is the first inflection point prior to the to the R wave. This inflection point is he recognized by a change in the sign of slope, zero slope, or a significance change in slope. If the ECG signal is noisy a low pass digital filter is applied to smooth the data before calculating the slope. The isoelectric line of the ECG must be located and measured. This is done by searching between the P and Q waves interval near-zero slope. In order o determine the QRS duration; the S point is located as the first inflection point after R wave using the same strategy s for the Q wave. Measurements of the QRS duration, R-peak magnitude relative to the isoelectric line, and the RR interval are then obtained.

In addition to the ST-segment level, several other parameters are calculated. The ST slope is defined as the amplitude difference between the ST-segment point and the point divided by the corresponding time interval. The ST area is calculated by summing all sample values between the J and T points after subtracting the isoelectric line value from each point. An ST index is calculated as the sum of the ST-segment level and one-tenth of the ST slope.

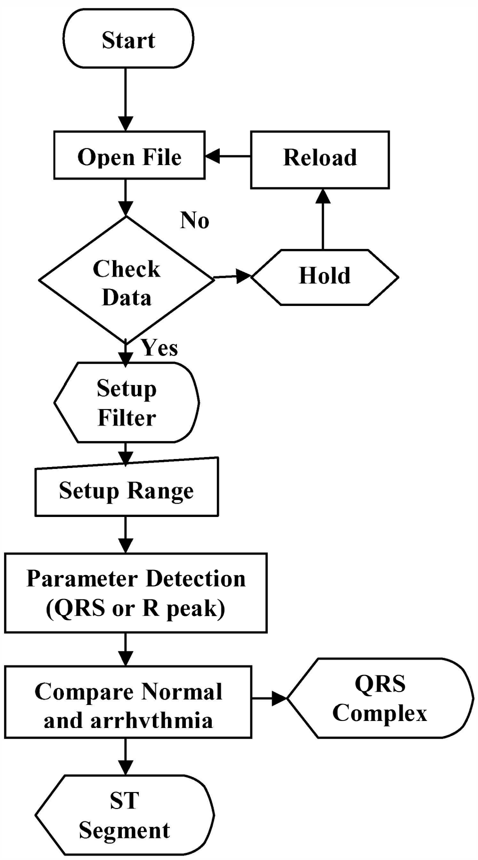


Fig.4. Detection of ST-Segment and QRS Complex.

ST database signal is used in order to operate plotting signal and detection algorithm. Automatic detection of ST segment obtained from Matlab programming tools. As shown in Fig.4 system comprises three separate parts: ECG data loading and open from database, signal parameter QRS detection of ECG signal and ST measurement of arrhythmia disease. The MIT-BIH ST is intended to be used for evaluation of algorithm for analysis of ST and T waves changes.

### B. *QRS Complex and R Peak Detection*

Already many algorithms have designed and implemented to perform signal processing for QRS wave detection such as 12 lead offline ECG analysis, Holter system analysis and real time patient monitoring. However to detect accurate QRS complex and R peak, first step is signal analysis. After analyzing various ECG signal from database, a typical bipolar QRS waveform is selected [11]. In our system, using method of least square optimization a pattern adaptive wavelet was generated [15] as shown in fig.4. A wavelet was adapted for the pattern using MatLab wavelet toolbox command. This adaptive wavelet is used for the discrete wavelet transform(DWT) analysis of ECG signals. An adaptive technique provide study of the least mean square(LMS) algorithm. Further it neither requires a measurement or knowledge of the correlation function and nor does it require matrix inversion.

Adaptive techniques are advantages because they do not require a prior knowledge of the signal or noise characteristics as do fixed filters. It provide estimated synthesis of desired signal and error feedback to modify the filter parameters. An adaptive filter learns the statistic of the input sources and tracks them, if they vary slowly and perform noise cancellation with signal extraction.ECG signals required for analysis were collected from global data source where annotated ECG signals are available [11]. MIT-BIH arrhythmia diagnostic database were used for testing of algorithm.

## IV. RESEARCH METHODOLOGY

### A. *Feature Extraction and Vector*

Feature extraction process is required to retain relevant information for original ECG signal. An efficient way of analyzing non stationary biomedical signal is through the wavelet transform. One of the benefits of wavelet transform is to enable decomposition of signals to extract energy of coefficients at each level. With this extraction coefficient, QRS complex or R peak noise is detected. Next, the zero voltage level onset point is identified and adjusted before Q wave and after S wave. Finally, T wave coefficient is extracted to detect noise at ST segment.

### B. *Denoising the ECG wave*

In biomedical signal processing, adaptive techniques are valuable for eliminating gradient noise interference. ECG recording one of the major problems is the appearance of an unwanted interference signal in output. Ventricular fibrillation detection has generally used frequency domain technique. Using the fact that fibrillation produces a prominent peak in frequency band. Adaptive filter operates as noise canceller. This approach of iteration modifying to minimized the error using LMS algorithm. It divided into: Firstly, filtering part tries to de-correlate the secondary input from output. Secondly, weight adjustment part tries to update the weight. It helps to feedback affected weight adaptation which ultimately results in better estimation.

### C. *Wavelet Transforms*

Wavelet transforms method find wide application not only in biomedical signal processing but in diverse set of field such as imaging, pattern recognition, data compression and numerical analysis. The important aspects of the wavelet transform that include its computation as localized in time, split signal into multiresolution component and compress energy of signal.Li et al had introduced an algorithm based on discrete wavelet transform (DWT) for the detection of characteristic of ECG [14]. Discrete wavelet transform analysis using spline wavelet for QRS complex is used kadambe et al [15].

Our algorithm involves discrete wavelet transform applied to discrete time signal to multiresolution decomposition. It enable the ECG signal to analyzed in different frequency bands by passing the signal into cascaded level at which the coefficients are obtained. Discrete wavelet transform detect short time, low energy transient change in normal QRS. Ventricular late potential (VLP) occurs due to weak signals, swapped by noise is detected using wavelet transform.

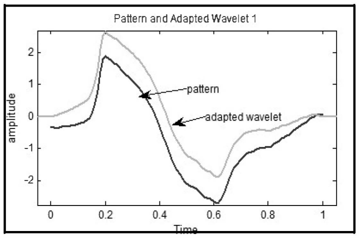


Fig.5. Adaptive wavelet. [16]

### D. Classification

Last stage is feature classification obtained by using support vector machine (SVM) technique. It is a concept in computer science for a set of relative supervised learning methods that analyze data and recognized pattern, used for classification and regression analysis. This principle incorporates theory coupled with extension and density estimation. The parameters are found by solving a quadratic programming problem with linear equality and inequality constraints rather than non convex, unconstrained optimization problem. The strategy of support vector machine is to keep the empirical risk fixed and to minimize the confidence interval, or to minimize the margin between a separating hyperplane and closest data points that is linear or margin classifier as shown fig. While use of non linear mapping is to transforms original data into higher dimension. By plotting different feature vector of ECG in clusters. Each cluster represents a different class could be normal ECG or arrhythmia ECG to obtain classification.

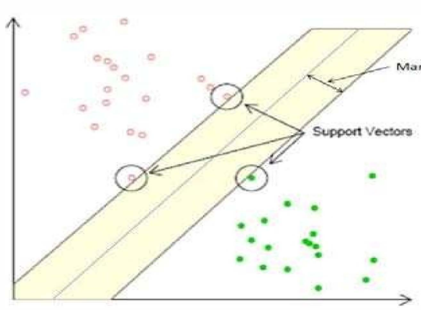


Fig.6. Margin and support vector in SVM. [13]

## V. Results and Discussion

Coronary heart disease arrhythmia is diagnosed by ECG signal analysis. Abnormalities in the ECG depend upon detection factors of change in amplitude and duration, or appearing noise. The propose approach focus on processing, analysis, detection and classification to improve accuracy and estimation. This is possible only by testing algorithm on different set of data. MIT-BIH arrhythmia database used to detect all characteristic peaks of PQRST waveform.

TABLE I. CHARACTERISTICS OF NORMAL ECG WAVEFORM

| | **Amplitude (mV)** | | **Parameter Duration (Sec)** |
|---|---|---|---|
| P Wave | 0.25 | RR Interval | 0.12 – 0.20 |
| R Wave | 1.60 | QRS Interval | 0.09 |
| Q Wave | 25% R wave | QT Interval | 0.31 – 0.44 |
| T Wave | 0.1 – 0.5 | ST Interval | 0.05 – 0.15 |

### A. Analysis

MIT-BIH database provide ST segment and QRS complex for analysis and evaluation of algorithm. It requires following three files: First, Header file has information of patient, lead, medication, clinical finding and recording equipment. Second, Data file has an ECG recording format of MIT-100. Third, Annotation file contains ST segment and QRS complex change start-peak-end, noise and rhythm information.

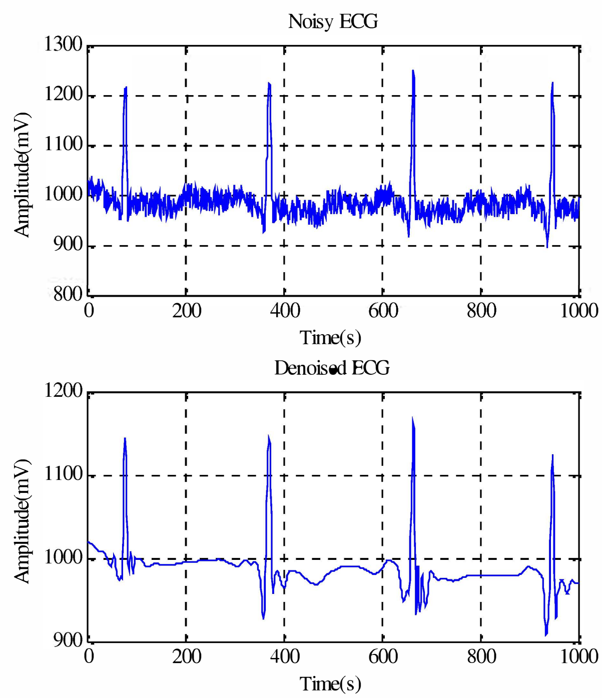


Fig.7. Denoising of ECG Signal

Further, ECG signal detection and analysis requires noise removal method and filtering. Our system proposed adaptive filter method in order to remove noise. For computerized detection of QRS complex based on threshold detection the main affecting noise factor will be baseline drift. Hence, adaptive filter are used to eliminate this baseline drift. With the use of Least Mean Square (LMS) algorithm the baseline of

ECG signal is subtracted from original to produce denoised signal.

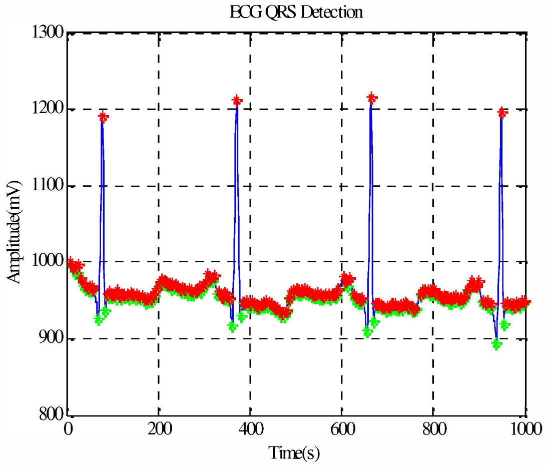


Fig.8. QRS Detection of ECG Signal.

In our study we have used a QRS pattern adaptive wavelet for discrete wavelet transform analysis of ECG signal to bring out high accuracy of R peak detection. As discrete wavelet transform performs a correlation study which is carried out with MatLab programming based wavelet tool. Even in presence of noise an adaptive wavelet gives better correlation. This paper proposed an accurate method to identify ECG characteristic through time frequency analysis. Hence, discrete wavelet transform proved as advantageous to carry out analysis of non stationary nature of cardiac cycle.

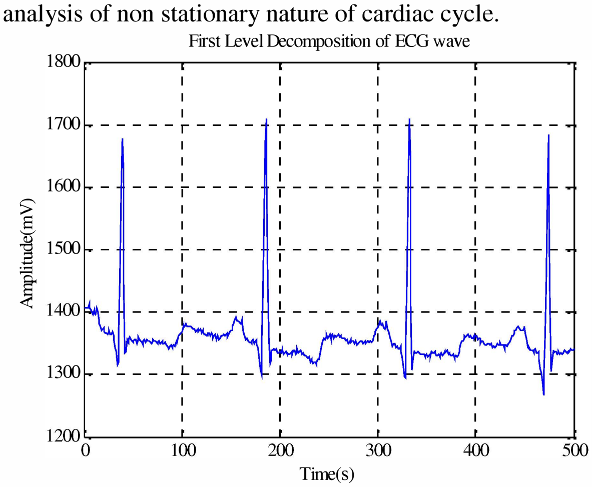


Fig.9. DWT coefficient at level-1

## *B. Classifier*

We tested and evaluated our system on the MIT-BIH arrhythmia database involved 11 record of 30 minutes. With the used of support vector machine classifier both morphological features and discrete wavelet transform best results are obtained as described in Table II. It is observe that our approach has achieved comparable or better performance in accuracy.

TABLE II
COMPARISON OF BEAT CLASSIFICATION APPROACHES ON MIT-BIH ARRHYTHMIA DATABASE

| Method | Ref. | Records | Performance Accuracy[%] |
|---|---|---|---|
| deChazal et. al | [9] | 22 | NA |
| Monebo | [11] | 48 | NA |
| Jun et. Al | [12] | 23 | 95 |
| Haseena et. al | [10] | 48 | 97.54 |
| Proposed | - | 11 | 98..65 |

## VI. CONCLUSION

An algorithm for ECG analysis of arrhythmia detection has provided peak detection accuracy of 98.65%. A study of adaptive wavelet approach with discrete wavelet transform obtained better performance in feature extraction of ST segment and QRS complex detection. Wavelet transforms approximation coefficients improve frequency in ventricular fibrillation and reduce noise using adaptive filter. Then, separate normal and arrhythmia MIT-BIH database are applied to support vector machine classifier to compare and achieved precise result of ECG signals.

## *References*


[1] J.Pan and W.L.Tompkins,"A Real-Time QRS Detection Algorithm,"IEEE Trans, Biomed Eng,pp:230-236.

[2] P.sasikala and Dr.R.S.D Wahida Banu "Extracion of P wave and T wave in ECG using wavelet transform"IJCSI,vol.2(1),2011,489-493.

[3] Duck Hee Lee[1], Jun Woo Park[2], Jeasoon Choi[3,"] "Automatic Detection of Electrocardiogram ST Segment: Application in Ischemic Disease Diagnosis" *(IJACSA) International Journal of Advanced Computer Science and Applications,* Vol. 4, No. 2, 2013.

[4] Suma C. Bulusu[1] and Subhash Banerjee[2] "Transient ST-Segment Episode Detection for ECG Beat Classification" NIH Life Science Systems and Applications Workshop (LiSSA) IEEE 2011.

[5] P. Ranjith, P.C.Baby, P.Joseph, "ECG analysis using wavelet transform: application to myocardial ischemia detection,"ITBM-RBM 24,2003,PP:44-47.

[6] J.S. Sahambi, S.N. Tandon, R.K.P.Bhatt, "Wavelet Based ST-segment Analysis",IFMBE, Vol. 36,1998.

[7] MIT-BIH Arrhythmia Database. *www.physionet.org/physiobank/.*

[8] M. Faezipour, T. M. Tiwari, A. Saeed, M. Nourani and L. S. Tamil, "Wavelet-Based Denoising and Beat Detection of ECG Signal," *in proceeding of* IEEE (LISSA, 2009).

[9] P. de Chazal, M. O'Dwyer and R. B. Reilly, "Automatic Classification of Heart Beat using ECG Morphology",IEEE Transactions on Biomedical in engineering,2004.

[10] H. H. Haseena, A. T. Mathew, J. K. Paul, "Fuzzy Clustered Probabilistic and Multi Layered Feed Forward Neural Networks for Electrocardiogram Arrhythmia Classification," *in Journal of Medical Systems, pp 1-10*, Aug. 2009.

[11] ECG Monitoring. *www monebo.com.*

[12] D. Jun and Z. Jia-wei, "Experiences-based Intelligence Simulation in ECG Recognition," in Proceedings of the IEEE International Conference on Computational Intelligence for Modeling Control & Automation(CIMCA 08), pp. 796-801, Dec. 2008.

[13] C.J.C. Burges, "A Tutorial on Support Vector Machines for Pattern Recogniton" , Laboratories, Lucent Technologies, Data Mining and Knowledge Discovery, vol 2, 1998, pp.121–167 .

[14] Cuiwei Li, Chongxun Zheng, and Changfeng Tai, “Detection of ECG Characteristic Points using Wavelet Transforms,” IEEE Transactions on Biomedical Engineering, Vol. 42, No. 1, pp. 21-28, 1995.

[15] Kadambe S, Murray R and Boudreaux-Bartels G F, “Wavelet transform-based QRS complex detector,” IEEE Trans. Biomed. Eng. 46 838–48, 1999.

[16] A. Matsuyama, M. Jonkman, “The Application of Wavelet and FeatureVectors to ECG Signals,”IEEE 2003.