ST Segment based ECG Signal Analysis using Matlab

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***Abstract*-Automatic detection of different types of heart abnormality is very useful for physicians and patients.it reduces the time for diagnosis. Most of the abnormality of heart diseases are detected from the ST segment variation in the ECG signal.(Hypercalcemia, Hypocalcemia, and ischemia).In this paper, the different types of diseases are classified by using ST segment variation in the ECG signal. The method includes several steps; ECG signal database loading, signal preprocessing, feature extracting using wavelet transform based on ST segment variation, finally display the classification results. Our system has been tested on the European ST-T Database for classifying four major groups includes Normal, hypocalcaemia, Hypercalcemia, ischemia, conduction loss**.

Keywords: Electrocardiogram, Wavelet Transform, SVM classification, Matlab.

I. INTRODUCTION

The Electrocardiogram (ECG) is an electrical recording of the heart behavior and is crucial to investigating cardiac abnormalities in a human. The ambulatory ECG recordings are typically examined visually by a physician for important feature the disease diagnosis time is reduced. Figure 1 shows a two cycle ECG recording with the fiducial points of importance; P wave, QRS complex and Twave. The heart diseases are clinically diagnosed by the study of ST-T complex. The changes in amplitudes, times and duration on the ST-T can indicate an electrical instability due to increased susceptibility to ventricular fibrillation and thus leading to sudden cardiac death. In particular, the ST-segment is the most diagnostic parameter as it represents a state of unchanged polarization.

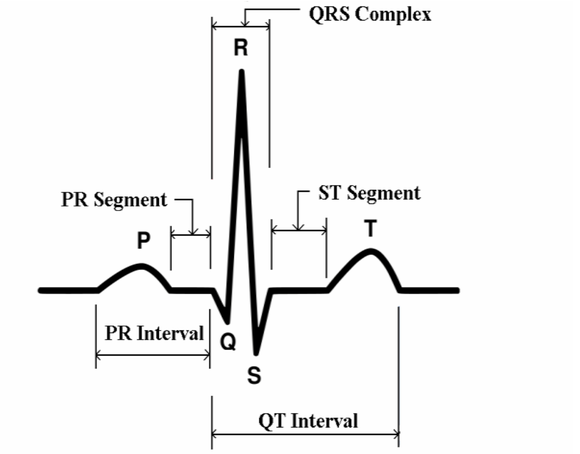

Fig1:Standard ECE signal

It begins at the offset of depolarization (QRS) and ends at the onset of depolarization (T wave), in the ECG. In prior researcher mostly classified the ECG signal diseases are ischemia, Fusion, Right Bundle and Left Bundle Branch Block but this paper includes the other diseases also, hypocalcaemia, Hypercalcemia, ischemia, conduction loss based on ST segment variation.

II. METHODOLOGY

The ECG signal are collected from the physionet, European ST-T Database in the .mat format using matlab to plot the ECG signal, the 50 Hz powerline interferences and baseline wandering is removed by using butterworth filters,the preprocessed signal is used to extracted the features using discrete wavelet transform,the support vector machine is used for classification.The workflow represented the method in fig:2

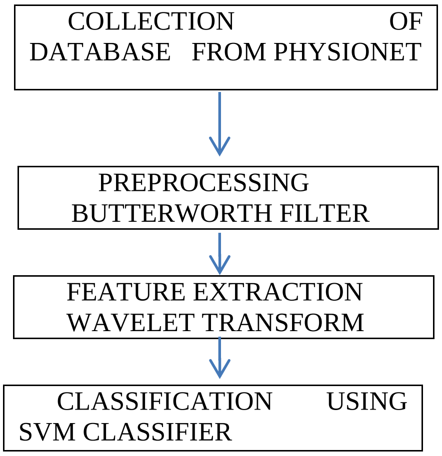

Fig2:Workflow diagram

A. PREPROCESSING

The electrocardiogram (ECG) is widely used for diagnosis of heart diseases. Good quality ECG is utilized by physicians for interpretation and identification of physiological and pathological phenomena. However, in real situations, ECG recordings are often corrupted by artifacts. Two dominant artifacts present in ECG recordings are: (1) High-frequency noise caused by electromyogram induced noise, power line interferences, or mechanical forces acting on the electrodes (2) Baseline wanders (BW) that may be due to respiration or the motion of the patients or the instruments. These artifacts severely limit the utility of recorded ECGs and thus need to be removed for better clinical evaluation. Several methods have been developed for ECG enhancement. In this paper, we propose the Butterworth (high pass) filter and the power line interferences are removed by Butterworth (stop band) filter.

B. WAVELET TRANSFORM

A wave is usually defined as an oscillatory function of time or space, for example, a sinusoidal wave. A wavelet is a short wave or small wave whose energy is concentrated in a time interval to provide transient analysis capabilities, non-stationer, or the phenomenon of time-varying. Wavelet can be used as a tool to perform mathematical decomposition of a signal into components of different frequencies, so that each component can be studied using the appropriate scale of resolution. Therefore, the wavelet is known as a tool to perform analysis based on the scale. Short waves have the advantage when compared to Fourier style shift methods in analyzing non-stationary signals. A wave is normally defined as an oscillation function of time such as sinusoidal waves. Fourier analysis is a wave analysis where this analysis expands signals or function of a sinusoidal wave having a periodic phenomenon, not changing time (time invariant), and stationary. The equation (1) represents the discrete wavelet transform (DWT).

$$T(m,n)= \int X(t)Y_{m,n}(t)dt \quad \text{limit}(-\alpha \text{ to } +\alpha) \quad \text{-------(1)}$$

By choosing an Orthonormal wavelet basis $Y_{m,}(t)$ we can reconstruct the original signal. In the short wave range over used term translation and scale, because the term of time and frequency is already used in the Fourier style shift. Translation is the location of the modulation window when it is slide along the signal, associated with timing information. Scale is related with frequency, high scale (low frequency) associated with the global information of a signal, while the low scale (high frequency) associated with the detail information.

B. SVM CLASSIFICATIONS

SVM is a new paradigm of learning system. The technique of SVM, developed by Vapnik, is a powerful, widely used technique for solving supervised classification problems due to its generalization ability. In essence, SVM classifiers maximize the margin between training data and the decision boundary (optimal separating hyperplane), which can be formulated as a quadratic optimization problem in a feature space. The subset of patterns those are closest to the decision boundary are called as support vectors. Consider a set of training examples (x1, y1),.....,(xl , yl),where input N. xi ∈ R and class labels yi ∈{−1,+1}. Decision function of the form sgn((w.x) + b) is considered, where (w.x) represents the inner product of w and x , w is weight vector and b is bias. It is necessary to find a decision function fw,b with the properties i = 1, ……, l

$$y_i ((w.x_i) + b) \geq 1 \qquad \text{--------------(2)}$$

Equation (2) is the basic formula of SVM for decision making. Using the support vector machine (SVM) classifier to classify the normal and abnormalities are Hypocalcaemia Conduction loss, Hypercalcemia, Ishcemia

IV. RESULT AND DISCUSSIONS

A. BUTTER WORTH FILTER

The input ECG signal shown in fig:3 which is taken from European database. It contain baseline wandering. By using butter worth high pass filter to remove the baseline wander as shown in fig:4. The power line interference removed by applying butter worth pass band filter to remove the power line interference using matlab. The cutoff frequency is 0.5Hz.normally the baseline wandering is occurring in low frequency up to 2Hz.

B. FEATURE EXTRACTION

The discrete wavelet transform is used to extracted the features.in this paper the R peak is detected by using Daubechis4 (db4) wavelet.Fig4 shows the detail coefficients.Fig5 shows the approximation coefficients for 4 levels.Fig6 shows the R peak detection in the 2nd level approximation.Fig7 determine the R peak in the actual ECG signal.Fig8 shows the PQRST points in the original ECG signal. the R peak used as the reference to other P,Q,S,T points. Then the ON time periods and OFF time periods of each epoch of Q,R,S,T are calculated from that the ST deviations are calculated. from that totally 8 features are extracted for 40 signal(40x8=320).

C. CLASSIFICATION

From the 8 features are extracted for 40 MIT-ST-T database. The multisvm package used for 5 types of classification includes Hypercalemia, Hypocalemia, Ischemia, Conduction loss and Normal Signal. the 18 signals are taken as the training and other signal used as the testing. Totally We got the 89.7% of efficient output for this 5 types of classification.Table1 shows the classification performance.

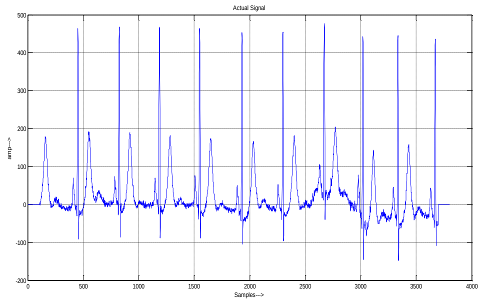

Fig3:Actual ECG signal

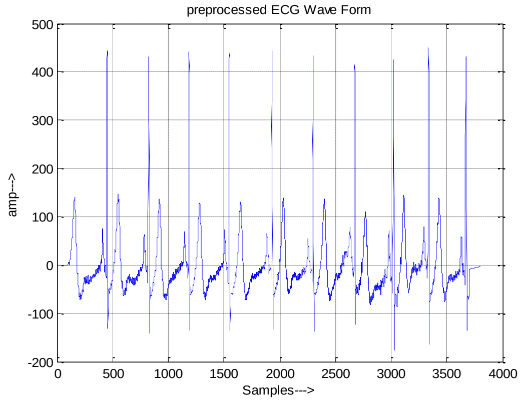

Fig4:Preprocessed ECG signal

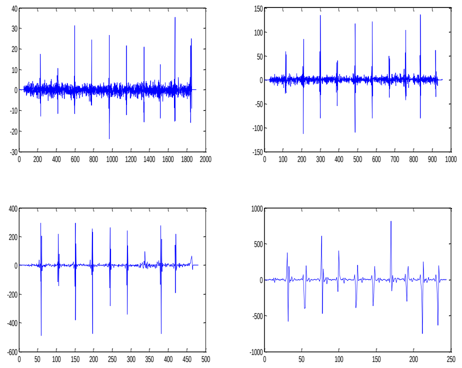

Fig5:Detail coefficients for db4 wavelet

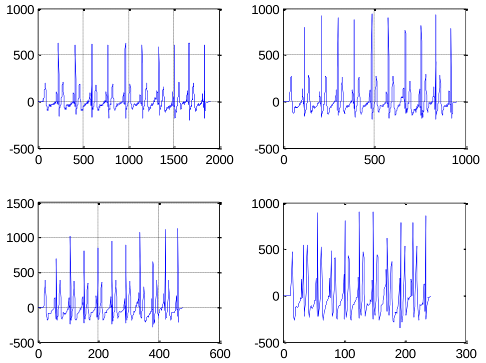

Fig6:Approximation coefficients

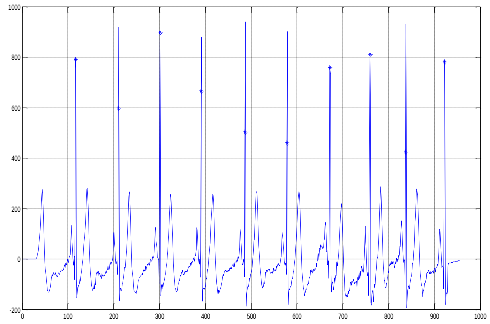

Fig7:R peak detection for 2nd level Approximation signal

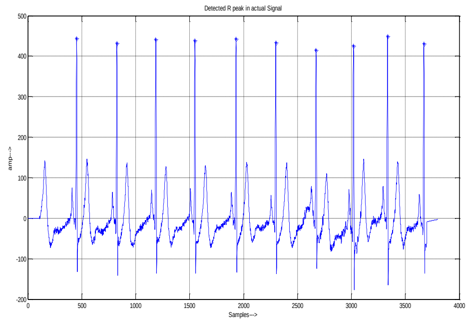

Fig8: R peak detection for actual ECG signal

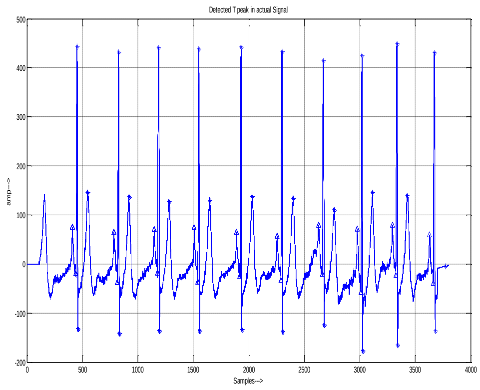

Fig9:PQRST detection in actual ECG signal

ECG Database	Sensitivity(%)	Specificity(%)
Hypercalcemia	83.3	100
Hypocalcemia	100	96.6
Ischemia	91.6	88.8
Conduction loss	66.7	93.9
Normal	83.3	90.9

Table1: SVM Classification performance

V. CONCLUTION

In this work an automatic detection of different types of diseases based on ST segment variation was developed. The Sensitivity, Specificity and Accuracy also detected. Future work must be oriented on more different types of heart disease classification based on P and QRS complex in ECG signal.

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