

Classification of Right Bundle Branch Block and Left Bundle Branch Block cardiac arrhythmias based on ECG analysis

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Abstract— Heart is a vital organ of the human body which plays an important role in the circulation of the blood throughout the body and also serves as the power source of the electrical impulses that generate the rhythmicity of the heart thus resulting in the successful circulation of the blood. Now any disturbance in the proper functioning of the heart results in some type of diseases termed as cardiovascular diseases or arrhythmias. These diseases can be diagnosed and consequently treated. The diagnosis is done by an efficient technique known as Electrocardiogram (ECG). This paper focuses on the area of biomedical signal analysis, where a method for detection of two types of cardiac arrhythmias namely Right Bundle Branch Block (RBBB) and Left Bundle Branch Block (LBBB) is discussed. The signal processing and analysis have been carried out on the data collected from MITBIH [1] database. Implementation is done on the MATLAB platform. The data collected from the MITBIH database are initially pre-processed and filtered by Savitzky–Golay filtering technique, smoothed and later subjected to feature extraction process where a number of features are extracted out and some computations are carried out. The results obtained from the feature extraction stage give us the idea of classifying the cardiac arrhythmias into the two types namely Right Bundle Branch Block (RBBB) and Left bundle Branch Block (LBBB). However the project is being extended to a classification stage where a Neural Network based classifier is proposed to be implemented in order to obtain better results.

Keywords: Arrhythmia; MITBIH; Savitzky–Golay filter; LBBB; RBBB; Multilayer Perceptron (MLP)

I. INTRODUCTION

The heart is a powerful muscle that pumps blood throughout the body by means of a coordinated contraction. The contraction is generated by an electrical activation, which is spread by a wave of bioelectricity that propagates in a coordinated manner throughout the heart. Under normal conditions, the sinoatrial node initiates an electrical impulse that propagates through the atria to the atrioventricular node, where a delay permits ventricular filling before the electrical impulse proceeds through the specialized His-Purkinje conduction system that spreads the electrical signal at speeds of meters per second throughout the ventricles. This electrical impulse propagates diffusively through the heart and elevates the voltage at each cell, producing an action potential, during which a surge in intracellular calcium initiates the mechanical contraction. The normal rhythm is altered when one or more spiral (reentrant) waves of electrical activity appear.

Any disturbance in the heart's normal rhythmic contraction is called cardiac arrhythmia [2] or simply arrhythmia. There are a number of cardiac arrhythmias like atrial fibrillation, bradycardia, tachycardia, left bundle branch block, right bundle branch block and many more.

The underlying cause of many arrhythmias is the development of a reentrant circuit of electrical activity that repetitively stimulates the heart and produces contractions at a rapid rate.

Cardiovascular diseases are defined as diseases and injuries of the cardiovascular system: the heart, the blood vessels of the heart and the system of blood vessels (veins and arteries) throughout the body and within the brain. Stroke is the result of a blood flow problem in the brain. It is considered a form of cardiovascular disease. Since 1952, the cardiovascular death rate in Canada has declined by more than 75 per cent and nearly 40 per cent in the last decade – largely due to research advances in surgical procedures, drug therapies and prevention efforts [3].

Heart disease and stroke are two of the three leading causes of death in Canada. Every 7 minutes in Canada, someone dies from heart disease or stroke. In 2008 cardiovascular disease accounted for 29% of all deaths in Canada (69,703 deaths or more than 69,500), 28% of all male deaths and 29.7% of all female deaths. In 2008, of all cardiovascular deaths: 54% were due to ischemic heart disease, 20% to stroke and 23% to heart attack. Nine in 10 Canadians (90%) have at least one risk factor for heart disease or stroke (smoking, alcohol, physical inactivity, obesity, high blood pressure, high blood cholesterol, diabetes).

Patients undergoing a seemingly uneventful recovery from myocardial infarction may develop cardiac arrest as a direct and immediate result of ventricular fibrillation. It is possible to treat and reverse many of these dangerous episodes if they could be detected early and an advance warning of their onset could be made available. One of the efficient methods of determining the type of cardiac arrhythmia is the extensive use of ECG examinations and analysis.

The electrocardiogram (ECG) is the electrical manifestation of the contractile activity of the heart. The ECG is characterized by a recurrent wave sequence of P, QRS, T and U wave associated with each beat. The QRS complex is the most striking waveform, caused by ventricular depolarization of the human heart. It provides information about the heart rate, rhythm, and morphology. The

importance of the electrocardiography is remarkable since heart diseases constitute one of the major causes of mortality in the world. ECG varies from person to person due to the difference in position, size, anatomy of the heart, age, relatively body weight, chest configuration and various other factors. [4] In this paper ECG analysis is done for the classification of arrhythmias RBBB and LBBB [5].

Right bundle branch carries nerve impulses that cause contraction of the Right ventricle. The two bundles start together at a junction called the bundle of His. Nerve impulses come through the sinus node of the heart to the bundle of His and then move into the bundle branches. During the RBBB, a right ventricle is not directly activated by impulses travelling through the right bundle branch.

Left bundle branch carries nerve impulses that cause contraction of the left ventricle the two bundles start together at a junction called the bundle of His. Nerve impulses come through the sinus node of the heart to the bundle of His and then move into the bundle branches. During the Left Bundle Branch Block, left ventricles are not directly activated by impulses travelling through the left bundle branch.

Constant research works are been carried out for the classification and detection of cardiac arrhythmias that implemented a number of techniques ranging from quantized threshold method for QRS detection [6], Correlation Coefficient [7] method for detection of cardiac arrhythmia in the ECG waveform, to construction of mathematical models for determining the shape [8] and form of QRS complexes for classification purposes. But all these above mentioned methods have some constrains like complexities of the techniques, less computation of statistical parameters.

In this paper an attempt is made for classifying the two types of arrhythmias namely RBBB and LBBB following a thorough of methods and techniques like preprocessing, filtering and feature extraction steps followed by a classification stage.

II. METHODOLOGY

A flow of different methods is implemented for the analysis process. The different steps involved are depicted in the following block diagram.

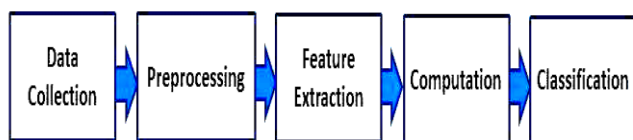


Fig 1: Block diagram for the ECG signal analysis

The raw data is collected from MITBIH database. The analysis is done here on an experimental basis taking into account of 12 lead systems. For both the cases, we have used the 12 lead dataset. While going through the database, it is found that the LBBB and RBBB features are prominently noted in leads I, V1 and V6. The algorithm and the further

processes are carried out taking into account of these three mentioned leads.

After the collection of data, we go for the pre-processing stage. In this stage, the original signals containing the noisy and baseline wandering noises are filtered out implementing fast Fourier transform over the signals with sampling frequency of 360 Hz. After this stage further filtering and smoothing is carried to remove the high frequency components by Savitzky–Golay(S-Golay filter) [9] with polynomial order of 6 and frame length of 21.

Next stage is the feature extraction stage. This is the most complex and lengthiest stage. When the input data to an algorithm is too large to be processed and is suspected to be notoriously redundant then the input data will be transformed into the set of features called as feature extraction. In this stage, each filtered and smoothed signal is analyzed for the feature extraction process. Here we try to detect all the peaks such as P, Q, R, S and T. The individual peaks are detected by applying some threshold parameters for each peak range and the respective peaks so obtained are plotted. Next we try to analyze the shape of complexes such as QRS, RsR', W shape and M shape patterns. Also we noted down the direction of T wave with respect to the QRS complex. Better results are seen in leads V1 and V6 for both the cases.

Following this stage, is the computation stage where we calculated the parameters such as duration of QRS complex, R peak time and RR interval.

Finally we come to the final stage, the classification stage. Currently we are working on this stage. We have planned to use the Multilayer Perceptron (MLP) [11] classifier where a large dataset is to be implemented for the classification process and to obtain the desired results with good sensitivity and specificity measures.

A. System Design

The following section describes the necessary prerequisites for carrying out the project. The prerequisites include both hardware and software components which are listed down

Hardware Requirements

- 1 GB Random Access Memory (RAM)
- Intel dual core processor
- 320 GB hard disk for storage

Software Requirements

- Operating System : Windows XP, WIN 7
- Software : MATLAB (version 7.10.0.499 (R2010a))
- Data collected form MITBIH database

B. Algorithm

The algorithm steps are listed below

Step 1: Raw ECG signals from MITBIH ECG database are taken.

Step 2: Filtering and smoothing of the signals are done by using Savitzky-Golay(S-Golay filter) filtering technique of polynomial order of 6 and frame length of 21.

Step 3: Carry out the feature extraction stage taking into account of all the 12 lead data

Step 4: Feature extraction is done for detecting the individual peaks, analyzing over the shapes of different complexes such as QRS, RsR', M and W shape patterns.

Step 5: Computation of some parameters such as QRS duration, R peak time and RR interval.

Step 6: If the amplitude and interval is similar to the standard normal ECG, our method will categorize it as normal. If there is deviation in the amplitude and durations etc. from the standard ECG, then that particular ECG is treated as diseases ECG.

Step 7: Then classifies the type of diseases as LBBB and RBBB using an MLP classifier.

C. RBBB and LBBB Characteristics

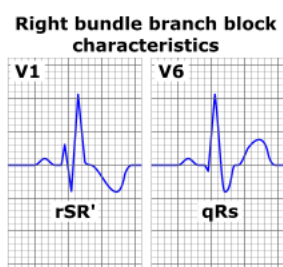


Fig 2: RBBB characteristics [10]

The above figure depicts the waveform of RBBB arrhythmia which is characterized with duration of QRS complex is equal or more than 120 ms, dominant R wave in leads V1, I and slurred wave in V6, (RSR') M shaped complex in lead V1 and W shaped in V6, Slurred S wave in lead V6, T wave is in the direction of QRS complex in V6 and inverted in leads V1 and I.

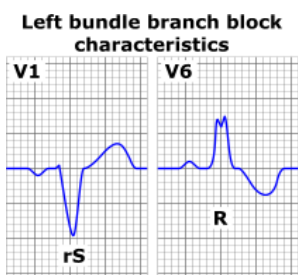


Fig 3: LBBB characteristics [10]

The above figure depicts the waveform of LBBB arrhythmia which is characterized by QRS equal or greater than 120 ms (adults), dominant R wave in lead V6 and dominant S wave in V1, T wave is in the opposite direction of QRS complex in V1 and same in V6, (RSR') M shaped complex in V6 and W shaped in V1.

III. RESULTS AND DISCUSSIONS

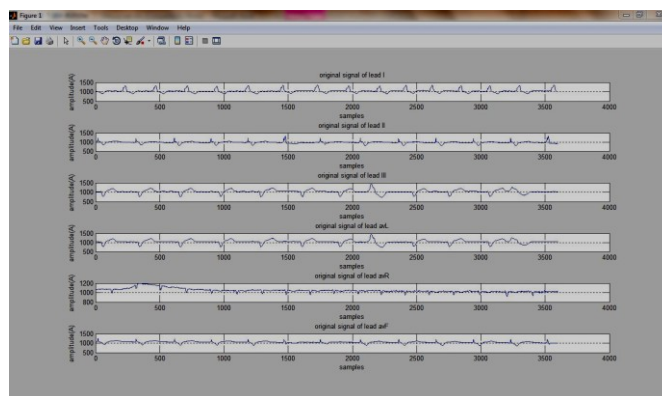


Fig 4: First 6 lead data of LBBB from MITBIH

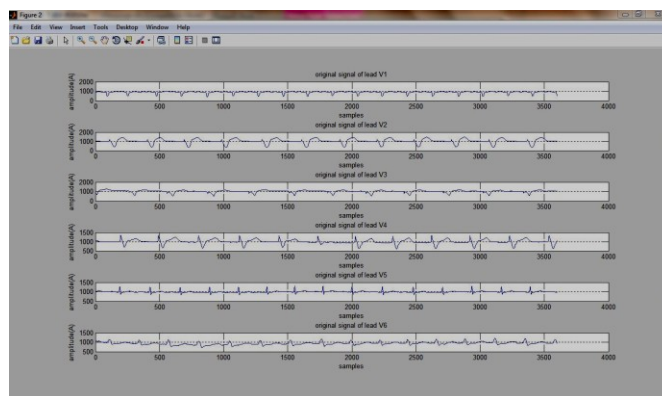


Fig 5: 2nd 6 lead data of LBBB from MITBIH

The 12 lead raw data is collected from the database and plotted as shown in figures 4 and 5. Similarly we plot the 12 lead data for the RBBB as shown in figures 6 and 7.

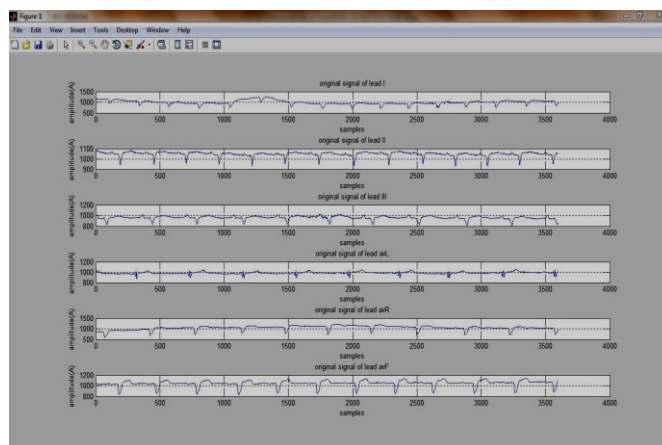


Fig 6: First 6 lead data of RBBB from MITBIH

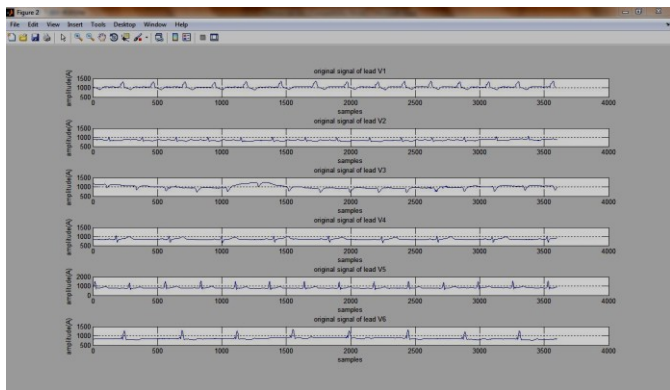


Fig 7: 2nd 6 lead data of RBBB from MITBIH

After plotting the original signals for all the leads, we apply our algorithm for each data lead data. However, we find the desired LBBB features in leads V1 and V6. The following figures show the filtering, smoothing and feature extraction stages for leads V6 and V1.

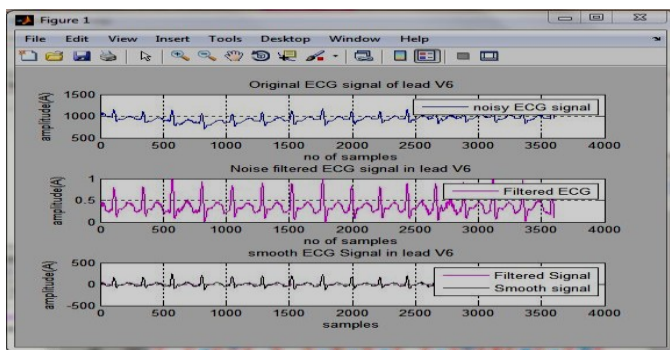


Fig 8: Filtered and smoothed V6 lead data for LBBB

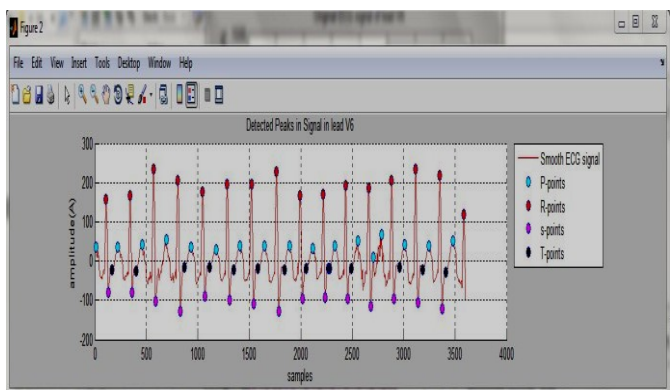


Fig 9: Feature extraction process of lead V6 for LBBB

After the feature extraction stage, we note the following features like dominant R waves, absence of q waves. The direction of T wave is in the same direction of QRS complex. An M-shaped R_sR' complex is seen. These features match the characteristics of LBBB.



Fig 10: Filtered and smoothed V1 lead data for LBBB

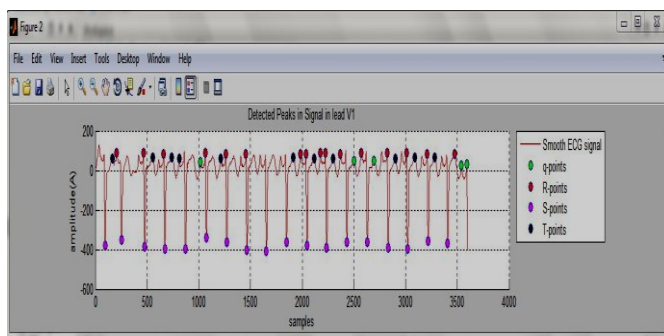


Fig 11: Feature extraction process of lead V1 for LBBB

After the feature extraction stage, we note the following features like dominant S waves, prominent rS pattern. Also the direction of T wave opposite to qRS wave/ Inverted qRS complex. A W shaped R_sR' complex is observed. These features also denote the LBBB characteristics. Similar approach is applied to the leads V6 and V1 for RBBB which are shown in the following figures.

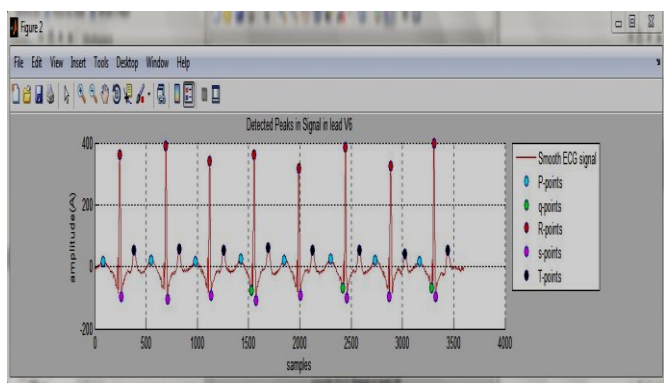


Fig 12: Feature extraction process of lead V6 for RBBB

After the feature extraction stage, we note the following features like qRs pattern; T wave is in the direction of QRS complex, wide S wave. A W shaped R_sR' pattern is seen. These features resemble the RBBB characteristics.

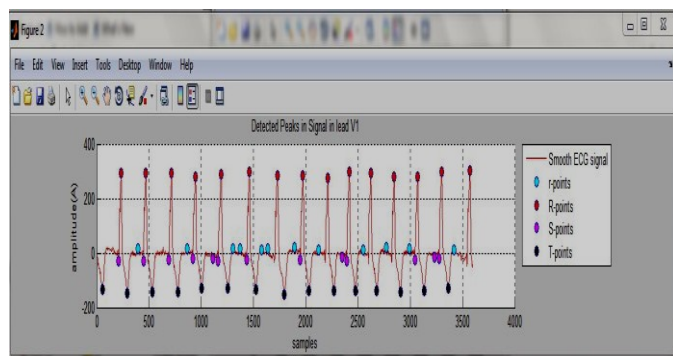


Fig 13: Feature extraction process of lead V1 for RBBB

After the feature extraction stage, we note the following features like dominant R waves, tiny r wave denoted in blue color dots, is seen forming the pattern rSR. The T wave is in the direction opposite to QRS complex. An M shaped RsR' complex is seen. So from the so far feature extracted process we have done the analysis for determining the shape of the complexes such as M and W shaped patterned complexes which are noted as prominent features of LBBB and RBBB.

The dominance of the individual wavelets such as R, S also helped in arriving at a better approach in classifying the arrhythmias. We further calculated some statistical parameters such as QRS complex duration, peak time for the R wave in order to increase the accuracy of the obtained results. Calculating the QRS complex duration we get a value of 130 ms which is quite close to 120ms.

Currently we are working on the classification stage. This is the last stage of our proposed work. Here we will be implementing the Neural Network based Multilayer Perceptron (MLP) classifier which will classify the diseases into three types namely normal, LBBB and RBBB. Constrain to this process is that it requires the training of a large number of datasets, but the method is undoubtedly a good one expecting a better sensitivity and specificity measures.

IV. CONCLUSION AND FUTURE ENHANCEMENT

The ECG signal analysis is done on the data collected from MITBIH database through a number of processing stages like pre-processing and feature extraction. The results are discussed in section 3. The leads V1 and V6 are mostly considered for the feature extraction process where individual peaks are found by thresholding technique, their direction of propagations and also some pattern shapes such as M and W are obtained. These followed by the computation stage where we computed the QRS duration and R peak time. The classification stage is in progress which will be implemented by NN based MLP technique that is supposed to yield good accuracy and sensitivity measures.

The implementation of the work is carried out on an efficient tool platform called MATLAB (version 7.10.0.499 (R2010a)). The algorithm discussed in section 2.2 is followed and so far results obtained are shown. The project is aimed at giving a better idea to the doctors and non-doctors about the classification of different types of cardiac arrhythmias.

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