A LABVIEW APPROACH FOR DETECTION OF CARDIAC ARRHYTHMIA

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Abstract*— Development of medical domain application has been one of the most active research areas as people have showing most of their interests for their health issues. Cardiac arrhythmia is becoming one of the leading causes of cardiovascular disease for men and women. Diagnosis and treatment of these conditions are usually achieved by using electrocardiogram signal (ECG)but detecting of heart diseases by using only ECG has some disadvantages so detecting heart disease by using other resources is better way. In this work LabVIEW based virtual system presented helps in de-noising, feature extraction, detection of heart rate, and automatic ECG abnormalities indicator. The designed system is advantageous for filtration of acquired signal or automatic removal of noise on virtual cardiographs and detection of P wave, QRS complex and T wave and then automatic indicate heart abnormality present in the signal. This designed have been tested on ECG database obtained from physionet.

***Index Terms*— ECG, LabVIEW, Biomedical Toolkit, Cardiac Arrhythmia**

I. INTRODUCTION

With the growing of global population there has also been a corresponding increase in chronic age related diseases such as heart failure, dementia, sleep apnea, cancer, diabetes, and chronic obstructive pulmonary disease [1].From last few years world is experiencing high rate of heart diseases that have become the leading cause of death. World Health Organization (WHO) states that cardiovascular diseases are the world's largest killers, claiming 17.1 million lives a year [2].In India more than 1.17 billion people are living(july,2009 estimation) that is more than one-sixth if world's population, experiencing heart related diseases and that is becoming the one third of all deaths caused by heart diseases[3].

Heart is one of the most critical organs in the human body so it is becoming critical to develop techniques that can examine its functionality. Electrocardiography is basically a diagnostic tool that is used to measure and record the electrical signals by comparing activity of heart. And this can be done by placing the electrodes on the body of the patient. Then current is passing through the body which stimulates the cardiac muscles that causes contraction and relaxation of the heart [4].At the end these electrical signals are characterized by peaks and valleys that are labeled by the letters P, Q, R, S and T.

The detection of QRS Complex of ECG signal has been researched from past three decades. According to the medical terms, the most important findings of ECG signal depends on P wave, QRS complex and T wave parameters [10]. To detect the QRS complex more accurately it is necessary to identify the exact R-peak location from the recorded data but the exact detection of QRS complex is difficult, as the ECG signal is added with different types of noise like electrode motion, power-line interferences, baseline wander, muscles noise etc.[6][7]. QRS detection activities have become very challenging to get the correct information from the ECG signal because of above written problems.

Section **II** discusses the background of ECG signal. Then Problem formulation is described in section **III**. Section **IV** describes the previous work related to cardiac arrhythmia detection**.** Section **V** shows the objectives to cover research work. Section **VI** describes methodology. Section **VII** will highlight Results. Section **VIII** will sum up the research work and future scope.

II. BACKGROUND

Electro-cardiograph is use to obtain an electrocardiogram (ECG) and electrocardiogram is use to represent the electrical activity of the heart graphically during cardiac cycle. A standard ECG signal is shown in fig.1 and a number of electrodes are kept on the patient's chest to obtain such standard ECG signal. Number of electrodes can vary depend upon which part of the heart are examined and it is from two to fourteen. The ECG estimates the variation in the electrical potential across the electrodes and that potential values are recorded and are transformed into a waveform after signal filtering and amplification.

When the system transmit the electrical signal through the heart with time, basic wave form used to show the electrical activity or ECG signal is shown in fig.1. The electrical system of heart is also known as the conduction system. ECG pattern is the combination of P-wave, T-wave and QRS complex that represents approximate location and intervals of ECG [5].

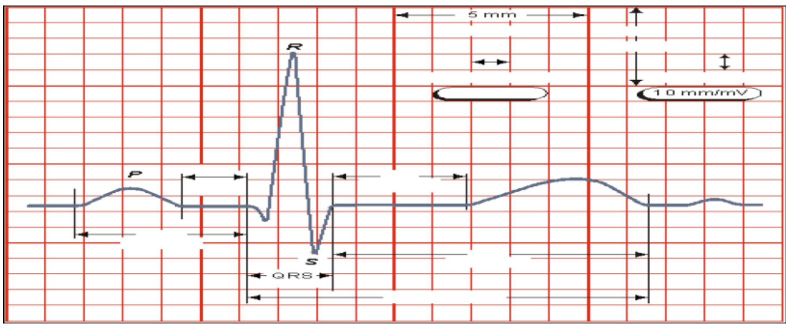

Fig.1 Different segment of Single waveform and time duration

The normal ECG parameters are shown in table 1.

Table 1.Normal ECG parameters

Phase	Duration	Amplitude
P wave	0.06-0.11	<0.25
PR interval	0.12-0.20	
PR Segment	0.08	
QRS Complex	<0.12	0.8-1.2
ST Segment	0.12	
QT Interval	0.36-0.44	
T Wave	0.16	<0.5

Any abnormality in cardiac rhythm is called as the Cardiac Arrhythmia and thus it may cause sudden death, dizziness, sudden death or no symptoms at all [7][8][9]. Some of the symptoms using clinical knowledge base and related diseases [17] are shown in Fig.2

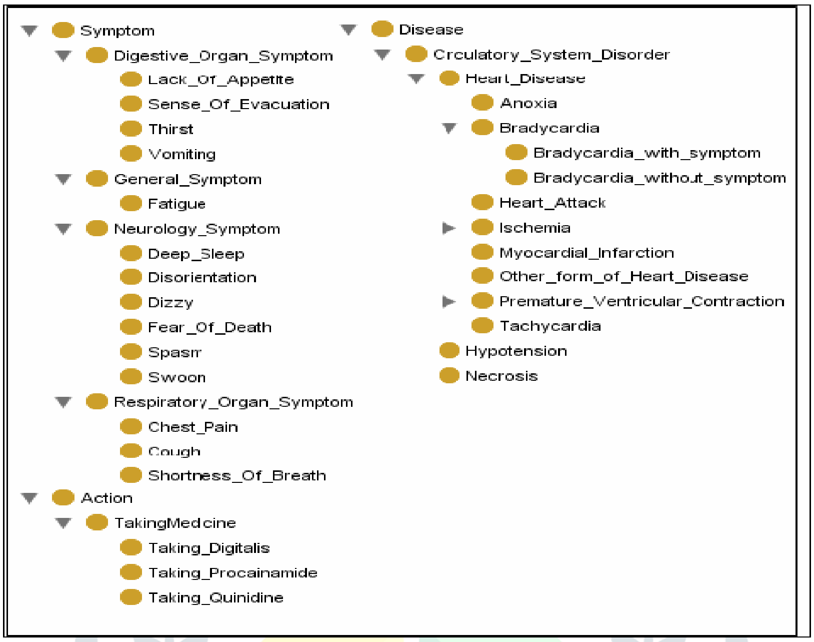

Fig.2 Ontology of Symptoms and diseases

After completing literature survey, the basic overview of various techniques for Cardiac Arrhythmia Detection from electrocardiogram signal is presented [19], [21], [23], [33]. The ECG waveform has been modified when filtered with different approaches.
The various numbers of techniques are implemented using different types of digital filters i.e. FIR and IIR filters [13], [37]. The filters are designed with different methods. The approach using novel Space is also used to get better results in phase space. Then QRS is also detected using different approaches and pan Tompkins approach is used in previous papers to detect accurate QRS complex [35].Other QRS complex detection approaches are reviewed from different papers[20], [26], [28]. Then feature extraction for detecting Cardiac arrhythmia using different techniques is discussed in [18], [11], [12], [13]. Applying these different techniques based on filtering, and feature extraction give good results to detect abnormality in the heart.

III. PROBLEM FORMULATION

During completion of literature review, the problems evaluated in my research area are briefly discussed as follows:

1. Early detection of Cardiac Arrhythmia is difficult. Although, a number of techniques had been used for detecting Arrhythmia using ECG signal but all those techniques used for are time consuming and expensive. As the early diagnosis can improves the prognosis and make effective treatment for patient.
2. Different types of noises contaminate the ECG signal. Contaminated ECG can cause false indication of Arrhythmia. Also ECG signal analysis is strongly affected by Power line and Baseline wandering noise.
3. For removing of baseline noise digital wavelet transform is used but the main drawback of digital wavelet transform is that it is not translation invariant.

IV. PREVIOUS WORK

In traditional approaches, the researchers have used digital filters for removal of noise as digital filter has high stability, frequency deviation range, computer based design, low cost implementation and more reliability as compared to analog filter. These filters were used along with windows like Kaiser, rectangular, hamming, etc. [37] for reducing the noise. We can also use the wavelet transform to remove baseline wandering by eliminating the trend of the ECG signal [13]. After that, de-noising is used and in previous approaches they used Digital Wavelet transform approach. The main drawback of DWT is not translation invariant. QRS complex is detected using pan Tomkins method in previous approaches. Then DSP based, k-mean clustering based, fuzzy based arrhythmia detection systems are explained in previous work.

Therefore, there is a need to design a system that would check all the possible cases frequently and then give the best coefficients to give the better results.

V. OBJECTIVES

1. Design IIR band-pass Butterworth filter, Notch filter for power line removal.
2. Design wavelet de-trends and De-noise for baseline and wideband removal.
3. QRS complex detection by using peak valley detection.
4. Feature extraction of the ECG signal.
5. By using extracted features detect abnormalities
6. Compute the results.

VI. METHODOLOGY

A. Software

To display and analyze the acquired data we created a graphical user interface using the Laboratory Virtual Instrument Engineering Workbench (LabVIEW) software. For this purpose we installed NI LabVIEW 2013 (32bit) software on our PC. LabVIEW is a graphical programming language created specifically for the measurement and automation of systems and applications. This software also has a wide range of libraries for instrument control and communication over various platforms such as serial, Bluetooth, USB and many more. Furthermore, LabVIEW has a large number of analysis suites such as a mathematical toolkit and signal analysis among others. In LabVIEW we can connect direct hardware using Data Acquisition (DAQ) that is less time consuming process when detecting cardiac arrhythmia.
Nexus machine is also used to acquire ECG signals in my work and can then also be used as measurement files by converting the acquired data into excel sheet directly using the software.
In our work we use signal processing with block diagram and biomedical toolkit for ECG feature extraction.

B. Filtering

In this step the band-pass filter is created by combining a low-pass filter with a high-pass filter. Notch filter is attached to remove 60 Hz interference. Wavelet De-trend VI from LabVIEW software is used to remove baseline wandering. Wavelet De-noise VI is used to remove wideband noise in the ECG waveform.

C. Peak valley detection

After de-noising the signal is passed through multi scale peak detection for analyze the largest peak value and then multi scale valley detector to analyze the every rise and lag in the ECG waveform [35]. We can detect no. of peaks and valley present in the Waveform and can detect QRS complex from LabVIEW biomedical toolkit directly.

D. Feature extraction

The classification of cardiac arrhythmias can be achieve after extracting the features of each heart beat in the ECG signal and a good feature extraction methodology can accurately classify cardiac abnormalities. Several methods have been proposed for extracting features of one cardiac cycle. The features of one cardiac cycle may be time domain features or frequency domain features. In [34] Inan et al. found that morphological information along with timing information can provide high classification accuracy for larger dataset. The combining of wavelet domain feature with RR- interval features can achieve high classification accuracy as reported in [29].

E. Abnormality detection

In this step after peak and valley detection and feature extraction, a de-noised signal is passed through Tone extractor VI in LabVIEW to extract the frequency and amplitude of the ECG waveform. Then Formula VI is used to convert the frequency of the signal to beat per minute. In this way, this whole VI is designed to indicate directly five cardiac disorders that are Bradycardia, Tachycardia, Atrial tachycardia, atrial flutter, Atrial Fibrillation and it will also indicate normal ECG.

VII. RESULTS

The electrocardiogram signal is taken from the MITBIH Arrhythmia database from physionet.org then converted it into TDMS format. A Lab VIEW based system has been designed which acquires ECG data and processes it as shown in fig.3

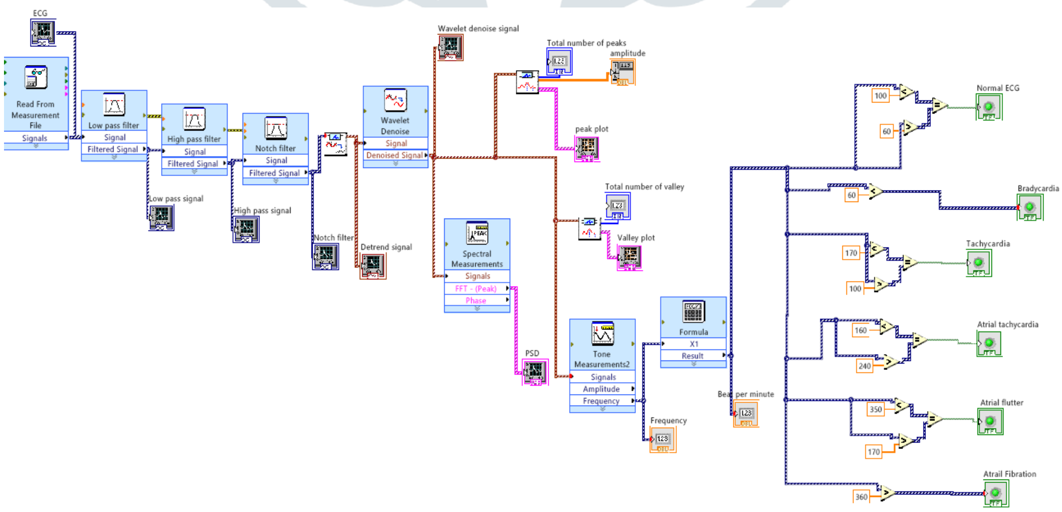

Fig.3 Complete Vi design for arrhythmia detection

The VI designed is able to acquire the data from measured file or simulate the ECG signal, processes the data, display ECG Arrhythmia waveform with 2000 samples. This recording includes two leads; the modified limb lead II and one of the modified lead V5 and MVII. The record is nearly about 30 minutes in length having sampling frequency of 360 Hz. The band-pass filter is created by combining a low-pass filter with a high-pass filter. Notch filter is attached to remove 60 Hz interference. Wavelet De-trend VI from LabVIEW software is used to remove baseline wandering and Wavelet De-noise VI is used to remove wideband noise using UWT in the ECG waveform. Then we take power spectrum of the signal as shown in fig.4 and fig.5.

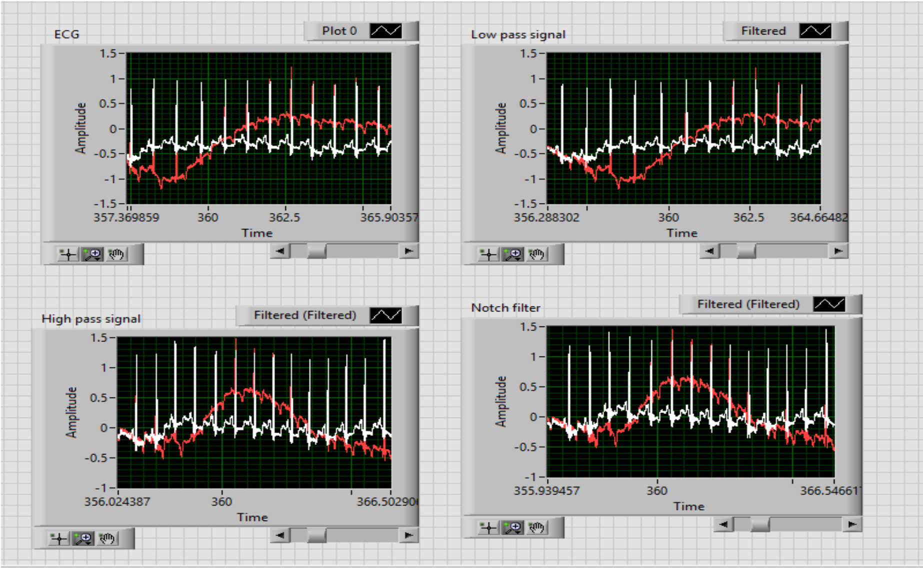

Fig.4 Simulating ECG signal and its filtering using various filter

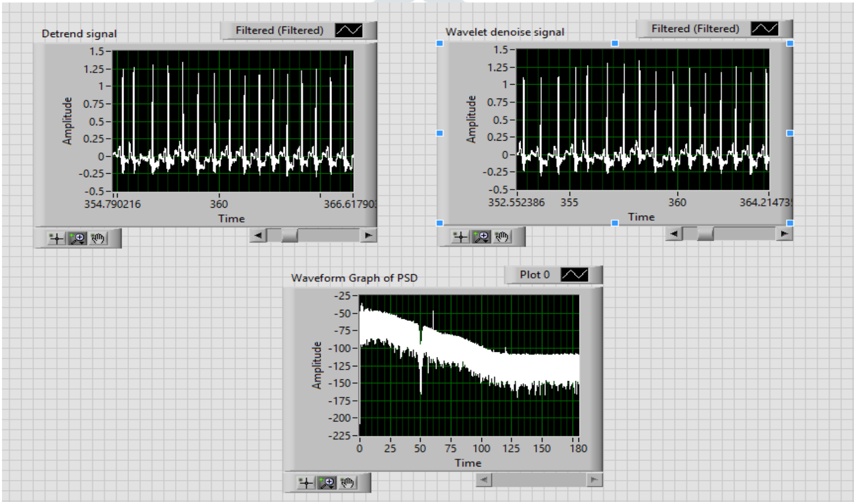

Fig.5 Wavelet de-noising and power spectrum analysis.

After de-noising the signal is passed through multiscale peak detection for analyze the largest peak value and then multiscale valley detector to analyze the every rise and lag in the ECG waveform and also calculate the number of peaks and valley present in the signal as shown in fig6.

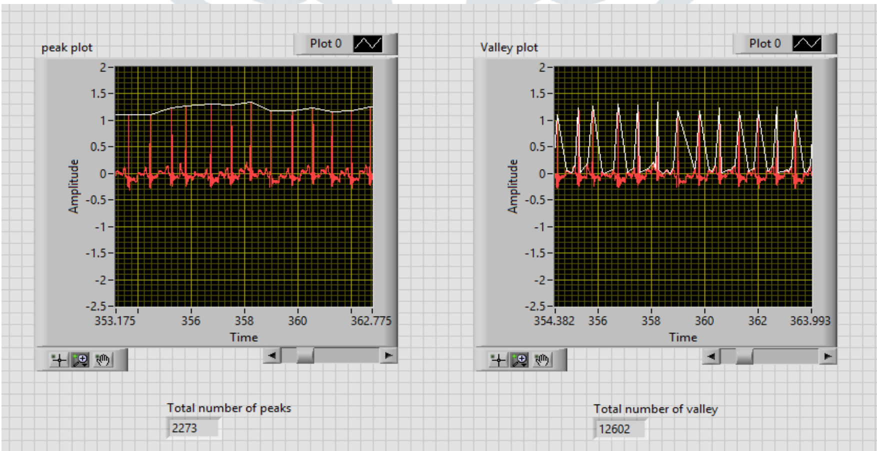

Fig.6 Peak and valley detector

After de-noising the signal is passed through multiscale peak detection for analyze the largest peak value and then multiscale valley detector to analyze the every rise and lag in the ECG waveform as shown in fig6. We can detect no. of peaks and valley present in the Waveform and can detect QRS complex from LabVIEW biomedical toolkit directly. After the peak detection the input data is transformed into a reduced representation set of features i.e. features vector and transforming the input data into the set of features is called feature extraction. Fig 7 shows the features extraction of processed ECG. Start Time of the signal is 00:00:05.5 and End time of the signal is 00:30:05.5.

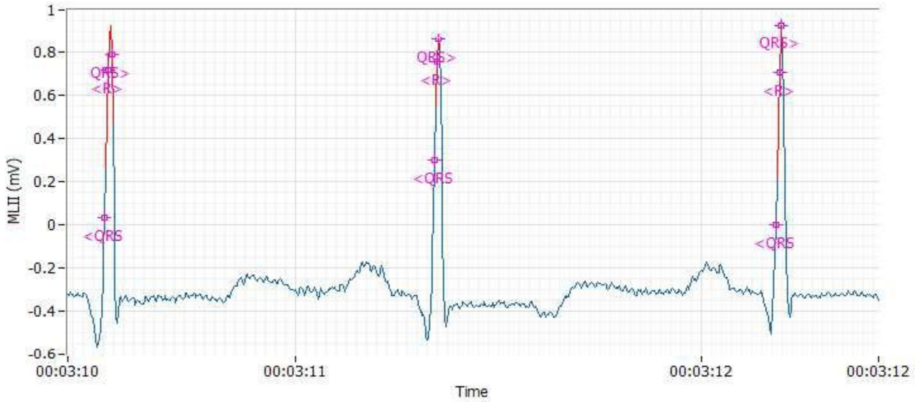

Fig.7 Feature extraction using biomedical toolkit

Then Tone extractor VI in LabVIEW to extract the frequency and amplitude of the ECG waveform is applied and by connecting the Formula VI to conditions or values for different diseases show the following results to indicate directly five cardiac disorders that are Bradycardia, Tachycardia, Atrial tachycardia, atrial flutter, Atrial Fibrillation and it will also indicate normal ECG results using input data as shown in fig.8 and fig.9 with frequency and BPM.

As from Fig.8 depicted that bpm for the data taken from Physionet [36] is 73.8995 which is normal, so it is indicating normal ECG.

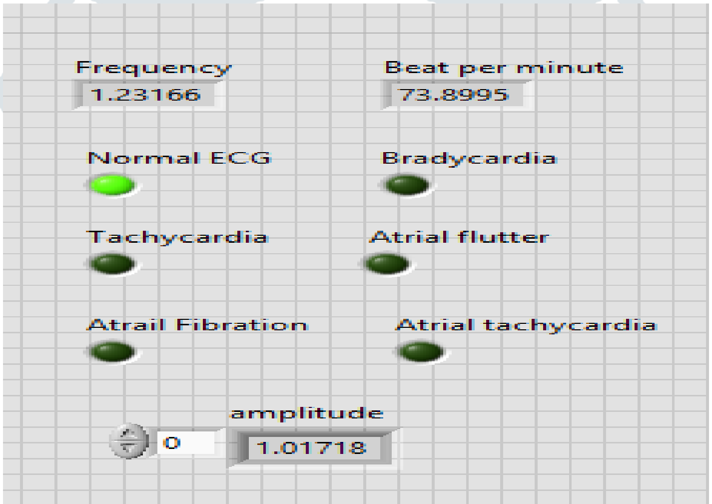

Fig.8 Indicate normal ECG present in input signal

For Fig.9, the results are obtained when input signal is changed using another data sample or in the same way we can take any ECG data in the form of TDMS to obtain the results as shown in Fig.9.

Fig.9 Indicate disease present in another input signal

VIII. CONCLUSION AND FUTURE SCOPE

To conclude, we have developed a double lead, LabVIEW based ECG system that can detect a common cardiac arrhythmia. The algorithm designed is able to acquire the data from measured file or simulate the ECG signal, processes the data, display ECG waveform, displays heart rate and its abnormalities. By using Lab View WA de-trend VI and Wavelet De-noise Express VI of Advanced Signal Processing tool Kit the baseline wandering and wideband noise in ECG signal data taken from MIT-BIH database 100 and sample data taken from biomedical toolkit has been successfully removed and also remove power line interference. Then feature extracted using LabVIEW biomedical toolkit and any abnormality present in input signal is indicated by blinking LEDs in Front Diagram of LabVIEW. The advantage of LABVIEW graphical programming language is that, it provides a robust and efficient environment and tool for generating very fast, less complex and useful algorithms. The virtual instrument can be very effective for an early detection of critical disease.

For real time applications Automatic cardiac abnormality detection is necessary. So, the Classification accuracy can improve by extracting the better features of ECG signal. Real time operation by connecting it with cell phones for recognizing the cardiac arrhythmias can also be done since the methodology uses the automatic detection of R-peaks, feature extraction and abnormality detection techniques.

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