International Journal of Pure and Applied Mathematics
Volume 119 No. 14 2018, 79-85
ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

An Efficient Real Time Arrhythmia Detector Model using LABVIEW

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Abstract

Human research and knowledge even after such advancement in the technology, available information is yet not capable of reducing or removing cardiac disorder. Hence there is a need for introduction of an instrument which can detect Arrhythmia and can help doctors to treat patients in a more improvised way. To develop such a device, we can use LABVIEW software which can help in real time testing of the ECG signals with great speed and accuracy. Therefore, the purpose of our project is to construct an arrhythmia detector that can detect and identify basic types of arrhythmia. Our model basically has two parts, hardware and software. Hardware part consists of 3 surface electrodes, instrumentation amplifier and filters. ECG is extracted from human subject using surface electrodes. Since these bio signals are weak in amplitude, they are passed through instrumentation amplifier followed by a low pass filter and then by a high pass filter and that is sent to LabVIEW software through an USB DAQ for further analysis. Software part includes analysis in LabVIEW using biomedical workbench. Feature extraction is done in LabVIEW software using wavelet transforms and peak detection algorithm. BPM ranges are set according to three cases like Normal, Tachycardia and Bradycardia. If arrhythmia is detected then through GSM module, the message of arrhythmia detection is sent to doctor in the text form.

Key words: *USBDAQ, ECG, BPM, Wavelet Transform, LabVIEW.*

1. Introduction

Arrhythmia is a case in which heart loses its rhythm of synchronous beating, this can be both painful and at times lethal too. Hence there is a need of introduction to an instrument which can detect Arrhythmia and can help doctors to treat patients in a more improvised way. For developing such detectors, we can use software products which can help in real time testing of the ECG signals with great speeds and accuracy. This bodes well for such a device being developed with significantly better accuracy and arrhythmia detecting capabilities and can further be linked with artificial intelligence software so as to detect any further occurrence of arrhythmias on the basis of the prior collected data patterns[1].

Preliminary detection and classification of cardiac Arrhythmia is one of the most important problems in biomedical signal processing. Computer assisted Arrhythmia recognition is critical for the management of Cardiac disorders. Arrhythmia is very common cardiovascular disease and there are more than 10 million cases per year [2].

Arrhythmia is a life threatening situation that requires immediate medical assistance. Continuous monitoring of patient is required, as there are no proper symptoms. Hence there is a need to develop of an instrument which can detect Arrhythmia and can help doctors to treat patients in a more improvised way.

The goal of this project is to develop a device that would replace the existing Electrocardiograms and facilitate doctors to record Electrocardiographs and detect basic arrhythmias simultaneously. With advent of technology and use of software like LabVIEW a virtual instrument can be designed which can be programmed by the users. Hence while developing Arrhythmia detector we choose to develop a hardware which would acquire the ECG signals and further amplify and filter it and then by means of a Data Acquisition Card the data can further be processed using LabVIEW software and the desired calculations can be performed and occurrence of basic arrhythmia can be detected.

Cardiac arrhythmias are one of the leading causes of cardiovascular disease(CD) for men and women. Diagnosis and treatment of these conditions are usually achieved using electrocardiogram (ECG) devices such as holter monitors, loop recorders and Implantable Cardioverter Defibrillators(ICD) among others. In this document, we report the development of a simple, single lead, real time ECG device intended for the monitor and detection of ventricular tachycardia(VT). Control software was developed using LabVIEW's biomedical toolkit and validated using simulated ECG signals [3].

2. Literature Survey

In [4] for extracting parameters of ECG we use wavelet transform, wavelet analysis breaks a signal down into its constituent parts for analysis. Mother wavelet transform that we use here is Daubechies of D6 family. If a signal is not well represented by one member of the Db family, it may still be efficiently represented by another. Daubechies wavelet family has similar shape to QRS complex and their energy spectrum is concentrated around low frequencies The wavelet transform is a convolution of the wavelet function ψ (t) with the signal x (t).

Orthonormal dyadic discrete wavelets are associated with scaling functions ϕ (t) [5].

In [6], many linear techniques for VT/VF detection have been developed, such as the probability density function method, rate and irregularity analysis, analysis of peaks in the short-term autocorrelation function, sequential hypothesis testing algorithm, correlation waveform analysis, four fast template matching algorithms, VF-filter method, spectral analysis, and time-frequency analysis. However, these methods exhibit disadvantages, some being too difficult to implement and Compute for automated external defibrillators (AED’s) and

Implantable cardioverter defibrillators (ICD's), and some only successful in limited cases. For example, the linear techniques using the features of amplitude or frequency have shown their limits, since the amplitude of ECG signal decreases as the VF duration increases, and the frequency distribution changes with prolonged VF duration. Therefore, more sophisticated signal processing techniques are needed to fully describe and characterize VT and VF and facilitate the development of new detection schemes with high correct detection rate, or equivalently, with low false-positive and false-negative performance statistics [6].

Curve Length Transform(CLT) is used for QRS detection and Discrete Wavelet Transform(DWT) is utilized for T and P wave detection. CLT offers a computationally efficient QRS detection technique. The CLT is pipelined and requires only one square, one square root and summation for each sample. And the DWT is implemented as cascade of filters [7].

The estimation of instantaneous frequency (IF) of an ECG signal is used as a method for carrying out detection of cardiac disorder. Based on IF estimates, a classifier has been designed to differentiate a diseased signal from a normal one. Training, testing and validation of the classifier has been carried out using signals from MIT Arrhythmia, normal Sinus Rhythm and Ventricular Arrhythmia databases, respectively [8]. The sensitivity and specificity of the classifier comes out to be 97.82% and 100%, respectively and it is considered especially suitable for ambulatory ECG analysis. The method normalizes the difference in the ECG morphology among subjects using dedicated wavelets. To evaluate the effectiveness of the normalization process, we compared five feature extraction methods. Those are a normal template cross-correlation (Template M), a discrete wavelet transform (DWT) with the Haar wavelet (Haar (7)), a DWT with the Daubechies 6 wavelet (db6(4)), a CWT with the dedicated wavelet of subject 106 (106CWT), and a CWT with the dedicated wavelet of each subject [9]. Each feature extraction method was applied to the ECG signals of the N class and V class, which were extracted from subjects who had over 100 heartbeats of the V class. Using the methods above, we compressed the output data to one-dimensional data via LDA. For 106CWT and Dedicated, we used the PCA-LDA composition, because these two methods are based on CWT. The compressed data was normalized to remove amplitude variation due to the different signal processing methods [14].

Arrhythmia detection and classification is by estimating IF of a single lead ECG waveform, rather than the usual RR interval time series. IF has been estimated by utilizing the method of average spectral density. The output of the IF estimator is utilized to design a classifier which differentiates a diseased signal from a normal one [15].

In [16] is to present a real-time detection method for cardiac event detection using the intra cardiac EGM signals. Sensed EGM signals differ from ECG signals in many aspects. Major differences are summarized here. EGM signals provide direct access to individual heart chambers, most importantly right ventricular and right atrial, at the signal source. In contrast, ECG signals provide a combined signal after propagation of various waves to the body surface. Relative timing of various
EGM signals is very important as it could be employed to discriminate various cardiac events accurately for ECG signals, however, such timing information is not available [16].

3. Design And Implementation

3.1 Block Diagram

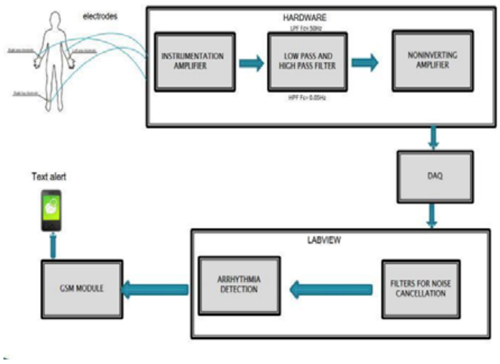

Fig. 1 Block Diagram of Arrhythmia Detector

ECG signals are extracted from the human body with the help of surface electrodes [15], the signals are passed through the instrumentation amplifier to reduce the noise. Then it is passed through the Low pass and High pass filter respectively. Now in order to get high gain the signal is passed through Non inverting amplifier. The output of Non-inverting amplifier is given to NI myDAQ [17]. DAQ is the interface between hardware and LabVIEW software. In LabVIEW feature extraction is made with the help of wavelet transformation and The arrhythmia detection is made with the help of peak detection algorithm. If Arrhythmia is detected, then the output will be sent as a text message to the Doctor using GSM module.

3.2 Pcb Circuit And Layout

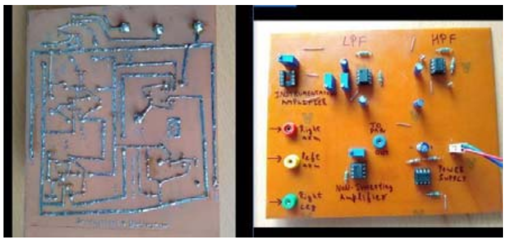

Fig. 2 PCB Circuit and Layout

The hardware circuit consists of amplifiers and filters. Supply voltage for all the filters and amplifiers is given by a 12V battery. It ensures the isolation of the circuit from the short circuit.

- Amplifier.
- Filter.

Amplifiers: The signal that is extracted from the wrist is of low amplitude, so the signal needs to be strengthened. We use INA 217 at the starting to amplify this signal. To amplify the output from the high pass filter we use a noninverting amplifier, which amplifies the signal so that it can be sent into DAQ.

Filters: Filters are circuits which perform signal processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones, or both. The filters used are Low pass filter (LPF) and High pass filter (HPF) [7, 21].

3.3 NI myDAQ

Fig. 3 NI myDAQ

It is affordable for student use and powerful enough for more sophisticated measurement applications [11,20]. Mac OS X and Linux users can download the NI-DAQmx Base driver software and program the USB6009 with LabVIEW. To supplement simulation, measurement, and automation theory courses with practical experiments, NI developed a USB-6009 Student Kit that includes a copy of LabVIEW Student Edition. It is used to interface hardware and software.

3.4 Labview

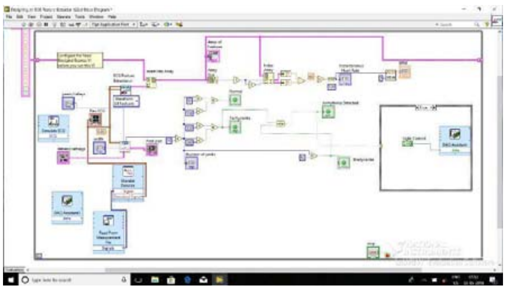

Fig. 4 Window Block Diagram

Software used for processing the signal by programming is LabVIEW. LabVIEW software is used to remove additional noise from the ECG signal and to detect arrhythmia. We make use of two panels or windows, one is the front panel and second one is the block diagram window. In front panel window the ECG waveform, peak plot, features such as P onset, P offset, QRS, T onset and offset, ST level, iso level, instantaneous heart rate, number of peaks [12,13] and arrhythmia detection display can be viewed. Feature extraction settings such as detrend settings can be changed. The block diagram window consists of blocks or graphical programs for arrhythmia detection and other features

3.5 Gsm Module

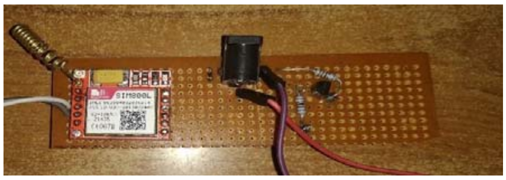

Fig. 5 GSM module

If arrhythmia is detected, then notification should be sent to doctor via GSM module. An alarming about abnormal functioning of heart can help doctors take appropriate measures at right time. Here we use SIM800 GSM module to communicate

3.6 Arduino Uno

Fig. 6 Arduino uno

In this project we use Arduino uno to control the GSM module we can enter the mobile number of the doctor and the message to be sent when the arrhythmia is detected in the Arduino software program. The Arduino UNO is a widely used open-source microcontroller board based on

the ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits [10].

4. Results And Discussions

The front panel of LabVIEW consists of raw ECG graphs, peak plot graph, BPM, instantaneous heart rate, number of peaks. There is a light notification for all three conditions i.e for normal, tachycardia, bradycardia. There is another light notification for arrhythmia detection, which turns red when tachycardia or bradycardia is detected and remains green when normal ECG.

On the right corner there is a array of features like P onset, P offset, QRS onset, R, QRS offset, T onset, T offset, amplitude, iso level, ST level, P wave, T wave.

The output of amplifier and filter circuit is fedto LabVIEW through DAQ. The signal goes through wavelet denoise block, wavelet analysis and feature extraction block. The detrend settings is used to remove the baseline wandering. Three types of inputs are used for analysis in LabVIEW, first one is through a simulation block, second one through DAQ assistant block and other one through read from measurement file block. Simulation block is used to give simulated signals, the DAQ assistant block can be used to give real time signal from the subject and read from measurement file block is used to give recorded signals or database signals(MIT-BIH) [18,19,21].

Here the BPM (beats per minute) is 40, hence the bradycardia condition button becomes light green from dark green. The arrhythmia detected button turns on red.

Fig. 7 Output for normal ECG signal

Here the BPM (beats per minute) is 80, hence the normal condition button becomes light green from dark green. The arrhythmia detected button remains off in dark green.

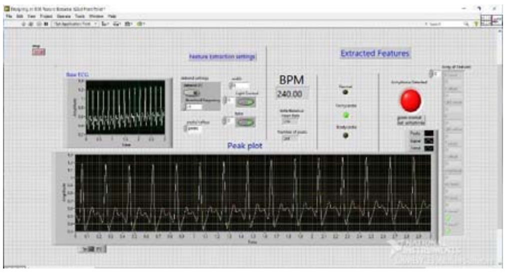

Fig. 8 Output for Tachycardia

Here the BPM (beats per minute) is 240, hence the tachycardia condition button becomes light green from dark green. The arrhythmia detected button turns on red.

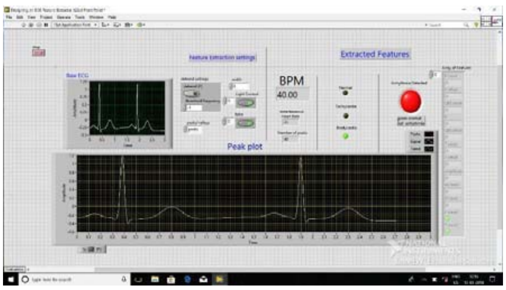

Fig. 9 Output for Bradycardia

Fig. 10 text alert to the doctor

The doctor takes appropriate measures to treat the patient after receiving this message. The doctor need not be present near the patients all the time.

Table of Test Results for Simulated Signal.

Input signal	**Expected output**	**Detected output**	**Condition detected**
Normal	Arrhythmia not detected	Arrhythmia not detected	Normal
Tachycardia	Arrhythmia detected	Arrhythmia detected	Tachycardia
Bradycardia	Arrhythmia detected	Arrhythmia detected	Bradycardia

Table shows the test results for simulated signal. The detected output is same as that of expected output. The accuracy is 100% in this case.

Table of Testing Results for Real-Time DAQ Input.

Patient name	**Patient condition**	**BPM**	**Expected output**	**Detected output**
shabarish	Normal	75	Arrhythmia not detected	Arrhythmia not detected
shwetha	Normal	85	Arrhythmia not detected	Arrhythmia not detected
charu	Normal	83	Arrhythmia not detected	Arrhythmia not detected
ramya	Normal	80	Arrhythmia not detected	Arrhythmia not detected

Table gives the testing results for real-time DAQ input. We tested on 4 patients, all are in normal condition so expected output is “arrhythmia not detected”. The detected output is same as expected output in all four cases, therefore accuracy is 100%.

Accuracy = 4/4 *100 =100%

Table of Test Result for MIT-BIH Database [18,19].

Input	**Existing condition**	**Detected condition**	**Detected output**
Normal 1	Normal	Normal	Arrhythmia not detected

Normal 2	Normal	Normal	Arrhythmia not detected
Normal 3	Normal	Normal	Arrhythmia not detected
Normal 4	Normal	Normal	Arrhythmia not detected
Normal 5	Normal	Tachycardia	Arrhythmia detected
Normal 6	Normal	Normal	Arrhythmia not detected
Normal 7	Normal	Normal	Arrhythmia not detected
Normal 8	Normal	Normal	Arrhythmia not detected
Normal 9	Normal	Normal	Arrhythmia not detected
Normal 10	Normal	Normal	Arrhythmia not detected
Tachycardia 1	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 2	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 3	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 4	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 5	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 6	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 7	Tachycardia	Tachycardia	Arrhythmia not detected
Tachycardia 8	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 9	Tachycardia	Tachycardia	Arrhythmia detected
Tachycardia 10	Tachycardia	Tachycardia	Arrhythmia detected
Bradycardia 1	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 2	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 3	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 4	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 5	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 6	Bradycardia	Normal	Arrhythmia not detected
Bradycardia 7	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 8	Bradycardia	Bradycardia	Arrhythmia detected
Bradycardia 9	Bradycardia	Bradycardia	Arrhythmia Detected
Bradycardia 10	Bradycardia	Bradycardia	Arrhythmia detected

Table shows the test result for MIT-BIH database. We tested on 30 patients, out of these only 28 are detected correctly. The expected condition is not same as detected condition for two cases, therefore the accuracy is 93.33%.

Accuracy= $^{28}/_{30}$ * 100= 93.33%

Sensitivity = $\frac{19}{19+1}$ *100= 95%

Specificity 9/(9+1) * 100= 90%

Table of Comparison of Accuracy

Author	Database	No of samples	Parameter considered	Accuracy obtained
P. Keerthi priya, 2015	MIT-BIH	19	QRS Complex	86.61%
Sanket Rege, 2015	MIT-BIH	3(100,101, 200)	QRS Complex	Not mentioned
Ping cheng, 2017	MIT-BIH	50	QRS Complex	92.69%
Proposed Project	MIT-BIH	30	BPM	93.33%

4. Conclusion

This project can provide doctors with better information related to patient's heart conditions and help them to identify further chances of occurrences of arrhythmia. In future it can be modified to detect other types of arrhythmias. The software part i.e LabVIEW virtual instrument block window and the front panel can be used with even other ECG extraction hardware. The major advantage of using the methods used for arrhythmia detection in this model is that the parameters of the code can be easily changed and customized to an individual's unique heart waveform.

An individual's waveform may change over the course of years, or the waveform may vary from person to person with respect to his or her age and condition of heart and his or her health and fitness. By adjusting the parameters which determine whether an event has taken place in the subject's unique waveform, either a beat or particular feature of an arrhythmia, the code will detect fewer false parameters. The code will detect the features of the arrhythmias with very good accuracy; however, it is still may not be correct all of the time. An improvement would be to increase the accuracy of the code.

Model has been tested for three different input sources, real time input, simulated input and input from MIT-BIH data base. The model proves 100% accurate for real timeinput and simulated input. 93.33% of accuracy is obtained for 30 samples from database collected from different individuals. Performance metric such as sensitivity and specificity are also calculated and found to be about 95% and 90% respectively. Results obtained from implemented model is compared with other published models and proves better for parameters considered.

5. Future Work

Making the device portable: By using wireless electrodes which can transfer the received ECG signals via GPS or Bluetooth or any such wireless transmission software, to a remote computer or Laptop having the Arrhythmia Detector so that it can be continuously monitored. Can include detection of more types of Arrhythmias: Currently the Project module is just detecting a selected few types of Arrhythmias which occur on regular basis. In future other arrhythmias like PVC, flutters, Atrial fibrillation, ventricular Fibrillation can also be introduced for detection. To interface the equipment with artificial intelligence soft-wares to detect any further occurrence of such arrhythmias. This can be achieved by comparing existing simulated patterns with the patient ECG and by doing Template matching so as to detect any similar patterns before an occurrence of an arrhythmia.

Acknowledgement: We sincerely acknowledge the support and assistance of our final year graduating students in carrying out this work.

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