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QRS Complex Detection and Monitoring Heart Abnormalities in ECG

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Abstract

An Electrocardiogram (ECG) is a biological signal and non-invasive method to record the electrical activity of the heart by electrodes placed on surface of human body. Acquiring and analysis of Rwave, can be done traditionally using different software. To be in advance this work focuses not only on acquiring and analysis of ECG signal but also on identification of cardiac abnormalities. This would bridge the gap between medical physicians and engineers. Our project is carried out with the help of Lab VIEW software. This model works for identifying particular abnormality. The signal is then fed to PC through NI ELVIS DAQ. Here the waveform in analog form is are converted to digital form and is analyzed for detecting the R peak of the ECG signal acquired, based on which the identification of cardiac disorders is done by sending them to the loops containing the conditions for cardiac disorders. Based on the results obtained from the analysis of the ECG signal and comparison with the loop conditions, the cardiac disorders identified and displayed instantly.

Firstly, denoising can be done by using WA Detrend and Undecimated Wavelet Transform (UWT), then features extracted from the denoised ECG signal by using ECG Features Extractor. One cardiac cycle in an ECG signal consists of the P-QRS-T waves. The amplitudes and intervals value of P-QRS-T segment determines the functioning of heart of every human. QRS detection, especially detection of R wave in heart signal, is easier than other portions of ECG signal due to its structural form and high amplitude. R wave is one of the most important sections of this complex, which has an essential role in diagnosis of heart rhythm irregularities and also in determining heart rate variability'.

Keywords: ECG (Electrocardiogram), Rwave, Lab View, NI ELVIS DAQ, Undecimated wavelet transform (UWT), P-QRS-T,

1. INTRODUCTION

Patient monitoring is now becoming more engrained in the delivery of everyday health care, distance education and also the health care administration. Lot of patients in underserved areas are receiving services that may not have otherwise received without travelling great distance or overcoming other transportation railing. Services are provided through-out the spectrum, from the youngest of patients to the weak elderly. Tele-health systems have many applications in hospitals, nursing homes, clinics, homes assisted living facilities, rehabilitation hospitals, schools, prisons or health departments.

It includes everything like medical services at the inpatient or at the outpatient stage. The doctors actually would like to see is constant monitoring of the essential parameters so they know all the time what the history is and how big the change from yesterday to today be and when you have these findings and have these data points available, then a much earlier intercession can happen for a patient. Patients who live in such type of areas can be seen by a doctor or specialist, who can provide an exact and complete examination, so that the patient need not to travel the normal distances like those from conventional hospitals.

In the recent past, it has been provided with a bio signal acquisition unit that is connected to a computer, vital signals can be transmitted from the hospital to any destination in a real-time mode or store-and forward mode.

The primary vision of current medicinal industry is to give better social insurance to individuals whenever and anyplace on the planet in a more financial and patient well-disposed way. Thusly to increase the patient care viability, there emerges a need to enhance the patient checking gadgets and make them more versatile. As the biomedical instrumentation and PC advancements[1] are propelling, it has turned out to be practical to outline an essential observing framework to obtain record, show and transmit the physiological flag from the human body to the specialist.

ECG has been comprehensively used for diagnosing many cardiac diseases. Various techniques and transformations have been proposed for extracting feature from ECG. This paper provides an overview of various ECG feature extraction techniques and algorithms proposed. The feature extraction technique or algorithm developed for ECG[2] must be highly accurate and evaluating the performance of different algorithms feature extraction should ensure fast extraction of features for ECG signal.

The wavelet transform has emerged over recent years as a key time–frequency analysis and coding tool for the ECG. Ability to separate out pertinent signal components has led to a number of wavelet-based techniques which supersede those based on traditional Fourier methods. In its continuous form, the CWT allows a powerful analysis of non-stationary signals, making it ideally suited for the high-resolution interrogation of the ECG over a wide range of applications. In its discrete form, the DWT[3] and its offshoots, the SWT and WPT, provide the basis of powerful methodologies for partitioning pertinent signal components which serve as a basis for potent compression strategies. The DWT has standard signal filtering and encoding methodologies and it produces few coefficients. The CWT[3], on the other hand, allows arbitrarily high resolution of the signal in the time– frequency plane, which is a necessity for the accurate identification and partitioning of pertinent components.

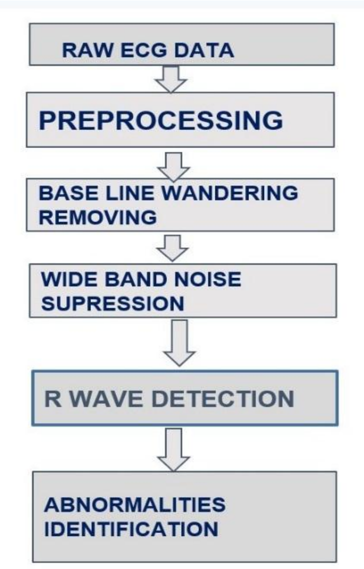

Fig: Computer-based signal acquisition, processing and analysis.

The computer-based signal acquisition, processing and analysis system using LabVIEW is used as peak detection tool in detection and filtering of biomedical signals. The computer-based patient education can help improve the patient's awareness and understanding of his or her disease, thus the efficiency of treatment can be increased.

The LabVIEW software is used as the integrating platform for acquiring, processing and transmitting the physiological data as it is an excellent graphical programming environment to develop sophisticated measurement, test, and control systems. The signal acquired here are ECG and TEMEPERATURE[5]. These signals acquired through sensors connected to PC having a LabVIEW platform through a DAQ device interfaced through an NI-USB 6210[4] having analog and digital input/output channels.

2. STAGES OF SIGNAL PROCESSING

Pre-processing state removes or suppresses noise from the raw ECG signal and the feature extraction state extracts the diagnostic information from the ECG signal.

The recorded ECG signal is often contaminated by unwanted signal and artifacts that can be range of the frequency band of interest and obvious with similar characteristics as the ECG signal itself. In order to extract the required information from the noisy ECG signal, we need to processes the raw ECG signal.

Pre-processing ECG signals remove contaminants from the ECG signals.

Broadly speaking, ECG contaminants can be classified into the following categories:

- Power line interference
- Electrode pop or contact noise
- patient–electrode motion artifacts
- electromyography (EMG) noise

Among these noises, the baseline wandering is the most significant and can strongly affect ECG signal analysis. Except for this noise, other noises may be wideband and generally a complex stochastic process which also distort the ECG signal. Generally, the ECG signal acquisition of hardware can remove the power line interference. However, the baseline wandering, and other wideband noises are not easy to be removing by hardware equipments. Instead, the software scheme is more powerful and possible for offline ECG signal processing.

PREPROCESSING

In general, the aim of pre-processing steps is to improve the general quality of the ECG for more accurate analysis and measurement. Noises may disturb the ECG to an extent that measurements from the original signals are unpredictable. The main categories of noise are: low frequency base line wander (BW) caused by the respiration and body movements, high frequency random noises caused by main interference (50 or 60Hz) and muscular activity and random shifts of the EEG signal amplitude caused by poor body movements and electrode contact[4]. A number linear and non-linear technique has been developed to eliminate these artefacts. The pre-processing comprises of three steps: removal of base line wander (elimination of very low frequencies) and removal of high frequency noise.

BASE LINE WANDERING

The BW is a low frequency add-on noise partially overlapping the band of ECG signal. This makes its removal difficult without affecting the ECG. In this work we propose a novel approach to baseline wander estimation and removal based on the idea of quadratic variation. It is a suitable index of variability for vectors and sampled functions. So, we derive an algorithm for baseline estimation which solves constrained convex optimization problem. The computational complexity of the algorithm is linear in the size of ECG record to detrend and making it suitable for real time applications. Simulation results confirm the effectiveness of the approach and highlight its ability to remove the baseline wander. Eventually, the proposed algorithm is not only limited to ECG signals[2], but also it can be effectively applied whenever baseline estimation and removal are needed, such as ECG records.

FEATURE EXTRACTION AND SELECTION

Each segment of an ECG signal may be represented by computed features (usually more than one) or by a combination of computed features. This part of the ECG processing process is crucial, because it provides the ability to distinguish between different classes. So, it directly affects the accuracy of final classification. The set of features is used may include the statistical and frequency features computed for typical and extended ECG bands[6], features obtained by interval or period analysis, entropy-based features, features extracted after application of the Wavelet Transform (WT), etc. In addition to this we have used information which is extracted from the other polygraphic channels. There are for example EMG, ECG, EOG, and PNG signals.

With feature extraction from ECG several hundreds of features can be acquired. This may be burdensome for further processing. The dimensionality of the feature space can be reduced by selecting the subsets of all features. There are various strategies and criteria for searching useful subsets of relevant features from the initial set of features. Feature selection is most important as it decreases the number of features that have to be measured and processed. In addition to improved computational speed in the lower dimensional feature spaces, there may be an increase in the accuracy of classification algorithms. In other words, feature selection is considered to be successful if the dimensionality of the data is reduced and the classification accuracy improves or remains the same.

TOOLKITS FOR SIGNAL PROCESSING USING LABVIEW

LabVIEW provides powerful tools, functions, and advanced algorithms for signal processing applications. These tools include ready-to-run stand-alone signal processing capabilities and tools for high-level digital signal processing (DSP), as well as built-in functions and add-on toolkits.

Typical applications for LabVIEW-based signal processing include analyzing test data and generating complex patterns, interfacing with DSP systems and real-world I/O, and easily building automated DSP test systems. LabVIEW offers a large variety of high-level signal processing functions with advanced mathematical algorithms[7], so you can easily integrate them into any application without having the problem about the underlying theory.

The various toolkits used in this project are:

1. **Advanced Signal Processing Toolkit**

The LabVIEW Advanced Signal Processing Toolkit includes the LabVIEW time series analysis tools, LabVIEW time and frequency analysis tools, and LabVIEW Wavelet Analysis Tools. These tools are a suite of high-level signal processing VIs that we can use to perform time and frequency, time series, and wavelet analysis to extract the underlying information of the signal.

2. **Biomedical Start up kit (Source code version)**

The source code of the biomedical startup kit few of the in-built codes for signal acquisition, analysis and visualisation.

We use the Biomedical VI’s and Express VI’s on the Functions>> User Libraries palette to create biomedical applications in Labview. These VI’s and Express VI’s enable you to perform the following functions.

- ECG and EEG simulation
- File input, such as loading and converting biosignals from various file types
- ECG preprocessing
- ECG feature extraction
- HRV analysis
- Median power frequency (MDF), Mean power frequency (MNF calculations),EMG RMS

3. THE PATTERN:

The Electrocardiogram (EKG) is a realistic following of the heart's electrical action. An average following comprises of a progression of waveforms happening in a tedious request. These waveforms emerge from a level benchmark called the isoelectric line[7]. Any redirection from the isoelectric line signifies electrical movement.

The five noteworthy diversions on an ordinary EKG are assigned by the letters P, Q, R, S, and T. One heart cycle is spoken to by a gathering of waveforms starting with the P wave, trailed by the QRS wave complex, and completion with the T wave. The P wave speaks to the depolarization of the atria and is related with their withdrawal. The QRS wave complex comprises of three waves[8]. The primary negative redirection is the Q wave and is trailed by a positive diversion called the R wave. The unpredictable closures with a negative diversion known as the S wave. The QRS wave complex indicates depolarization of the ventricles and is related with their compression. Atrial repolarisation happens amid the depolarization of the ventricles. Consequently, the waveform related with atrial repolarisation is imperceptible on an EKG. The last wave is known as the T wave and is normally spoken to by a positive redirection. The T wave shows ventricular repolarization. Electrical vitality is additionally created by skeletal muscle and can be viewed as muscle ancient rarities if your arm is moved while the EKG is appended. The grouping from P wave to P wave speaks to one heart cycle. The quantity of cycles in a moment is known as the heart rate and is regularly 70-80 thumps for each moment very still.

Some run of the mill times for segments of the EKG are:

P-R interim 0.12 to 0.20 seconds

QRS interim under 0.1 seconds

Q-T interim under 0.38 seconds

On the off chance that your EKG does not compare to the above numbers, DO NOT BE ALARMED! These numbers speak to run of the mill midpoints and numerous solid hearts have information that fall outside of these parameters[3]. To peruse an EKG adequately takes extensive preparing and expertise.

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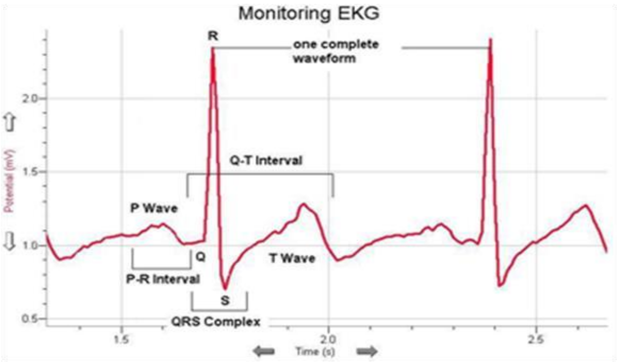


Figure 2.6

Heart Abnormalities:

"Arrhythmia" means your heartbeat is irregular. It doesn't necessarily mean your heart is beating too fast or too slow. It just means it's out of its normal rhythm.

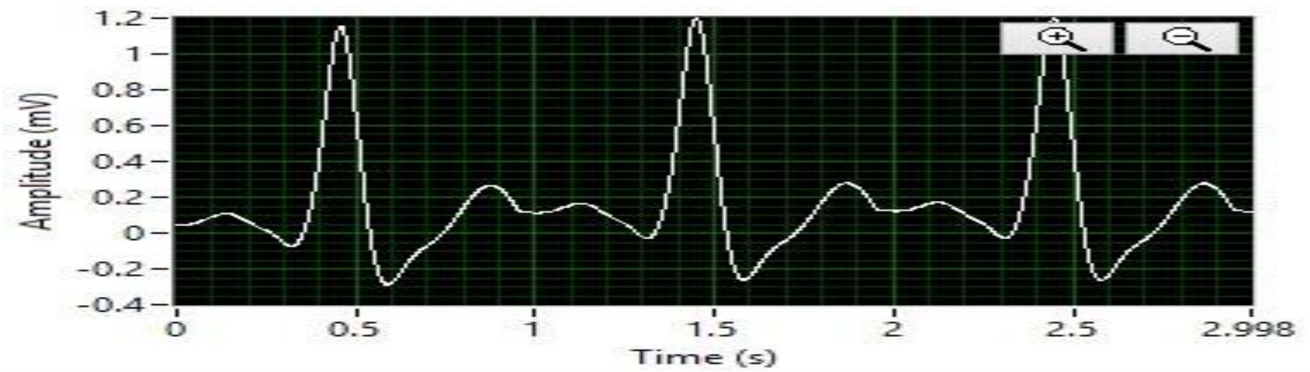
It may feel like your heart skipped a beat, added a beat, is "fluttering," or is beating too fast (which doctors call tachycardia) or too slow (called bradycardia). Or, you might not notice anything, since some arrhythmias are "silent."

Arrhythmias can be an emergency, or they may be harmless. If you feel something unusual happening with your heartbeat, call doctor.

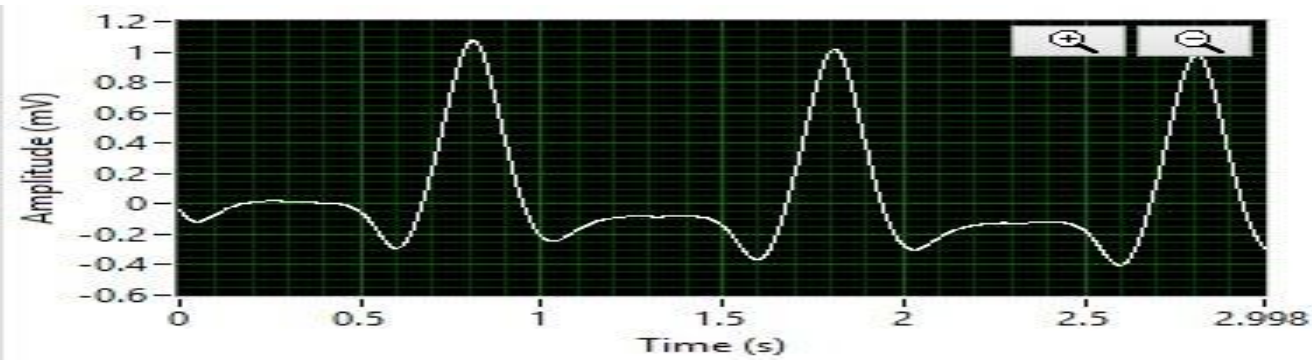
Table 1. Heart Abnormality and it's symptoms

Category	systolic, mmHg	diastolic, mmHg
Normal	90 – 119	60 – 79
Hypotension	< 90	< 60
Pre-hypertension	120 – 139	80 – 89
Stage 1 Hypertension	140 – 159	90 – 99
Stage 2 Hypertension	≥ 160	≥ 100

Normal ECG signal



Atrial Tachycardia



Ventricular Tachycardia

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4. HEART RATE

Heart rate is the speed of the pulse estimated by the quantity of withdrawals of the heart every moment (bpm).To shape a pulse, the pacemaker area of the heart (which is close to the upper right of the heart) starts to flame and the atria (the two best councils of the heart) contract. The SA hub creates a little electrical stun which invigorated a synchronized withdrawal. This is what defibrillators do when a heart has quit pulsating. At the point when a heart assault is happening and a patient is experiencing ventricular fibrillation, it implies that heart muscle cells are contracting haphazardly and not as one, so the heart trembles as opposed to pumping as an organ. Defibrillators synchronize the heartbeat with sudden surge of current over the heart to reset the majority of the phones to start terminating in the meantime (expresses gratitude toward Ron for asking for a more specialized depiction). In the event that a current is keep running over the muscle, the cells (cardiomyocytes) all agreement in the meantime and blood moves. The AV hub (nearer to the focal point of the heart) in blend with a moderate directing pathway (called the heap of His) control withdrawal of the ventricles (the extremely expansive chambers at the base of the heart), which deliver the extremely vast spikes we see on an ECG. The heart rate can change as per the body's physical needs, including the need to assimilate oxygen and discharge carbon dioxide. It is typically equivalent or near the beat estimated at any fringe point[7]. Exercises can incite change incorporate physical exercise, rest, tension, stress, sickness, and ingestion of medications.

The normal resting adult human heart rate ranges from 60 bpm – 100 bpm. Tachycardia is quick heart rate, characterized as over 100 bpm very still. Bradycardia is a moderate heart rate, characterized as beneath 60 bpm very still. Amid rest a moderate pulse with rates around 40– 50 bpm is normal and is viewed as typical. At the point when the heart isn't thumping in a consistent example, this is alluded to as an arrhythmia. Irregularities of heart rate infrequently demonstrate malady.

R-Wave detection

The QRS complex is comprised of three waves. These waves demonstrate the altering course of the electrical jolt as it goes through the heart's conduction framework. The biggest wave in the QRS complex is the R wave[4].The R wave is the principal upward redirection after the P wave (not withstanding when Q waves are truant). The R wave is regularly the most straightforward waveform to recognize on the ECG and speaks to early ventricular depolarisation.

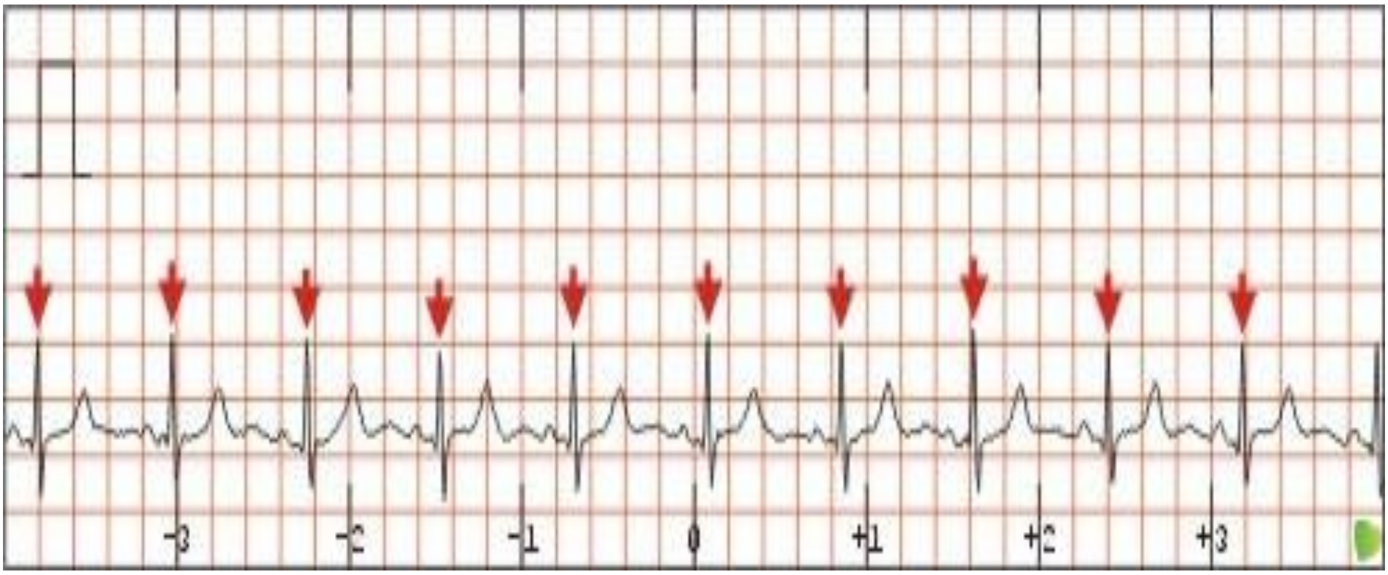

Figure4.1

QRS detection, especially detection of R wave in the heart signal, is easier than other parts of ECG signal due to its structural form and high amplitude.

R wave is one of the most important portions of this complex, it has an essential role in diagnosis of heart rhythm irregularities and also in determining heart rate variability

The Wavelet Transform is time-scale representation that is used successfully in a broad range of applications, in particular signal compression.

The Wavelet transformation is a linear operation which decomposes the signal into number of scales with respect to the frequency components and analyses each scale with a certain resolution .One of the benefit of the Wavelet Transform is that it can break down signs at different resolutions[2], which permits precise element extraction from non-stationary signs like ECG

Wavelet denoise performs the reduction of noise for 1D signals by using the discrete wavelet transform (DWT) or un decimated wavelet transform (UWT).

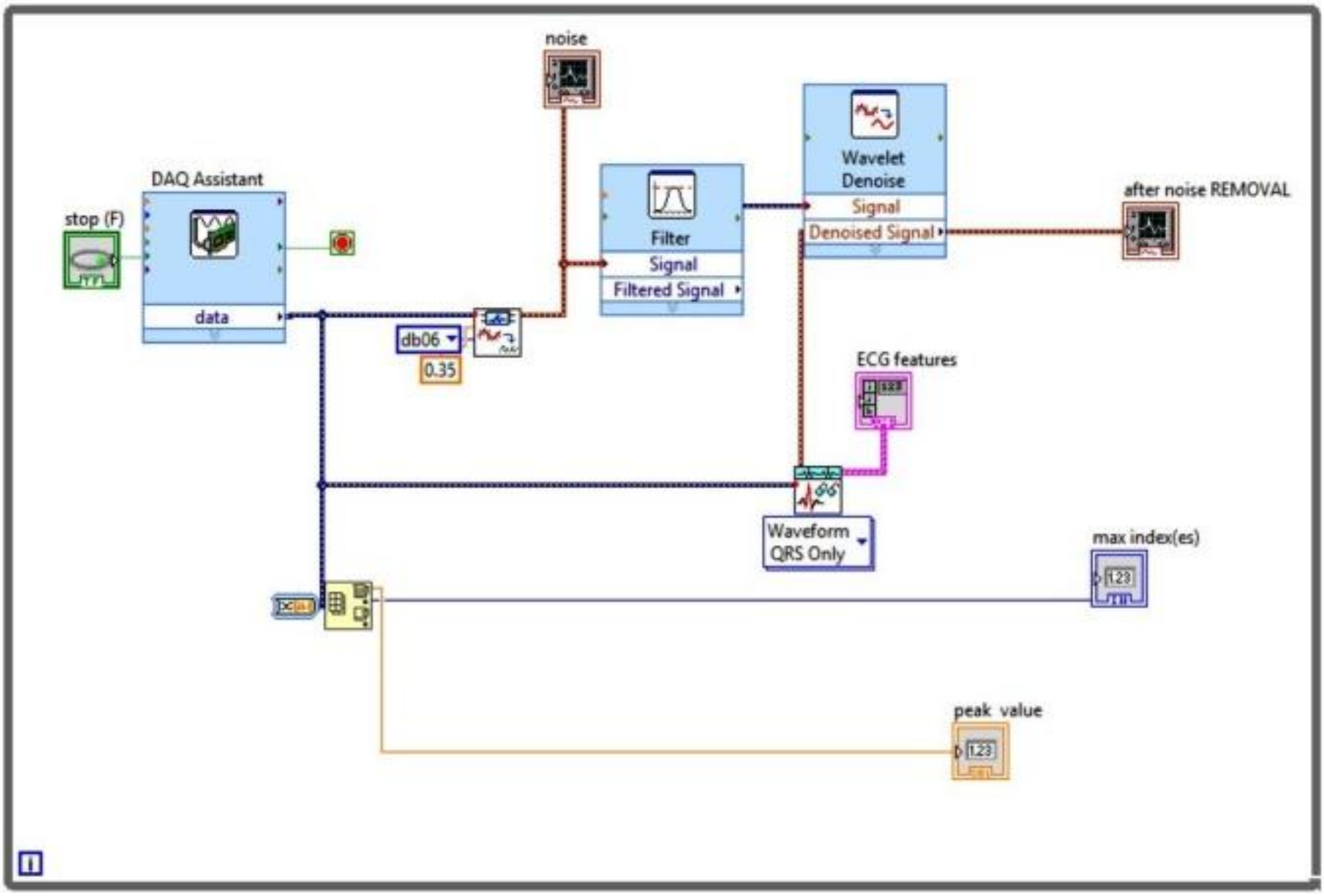

Figure 4.2

5. RESULTS

5.1 ECG Sensor-Result

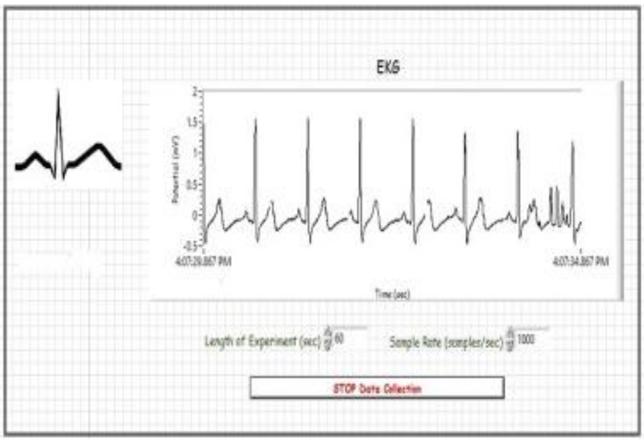

Figure 5.1

The readings obtained above EKG signals which were sampled at rate of 1000 and the experiment was carried out for 1 minute. The measurements were written to the file. However, this was not published on web.

Table 2. ECG Readings

	Person1	**Person2**	**Person3**
Time-Voltage	(0-9)V	(0-9)V	(0-9)V
Potential(mV) Voltage	0.583309	0.1066	0.072436

Therefore, from the obtained curve and readings there exists no abnormality detected.

5.2 ECG abnormality.

Person 1:

Figure 5.2

Person 2:

Figure5.3

Person 3:

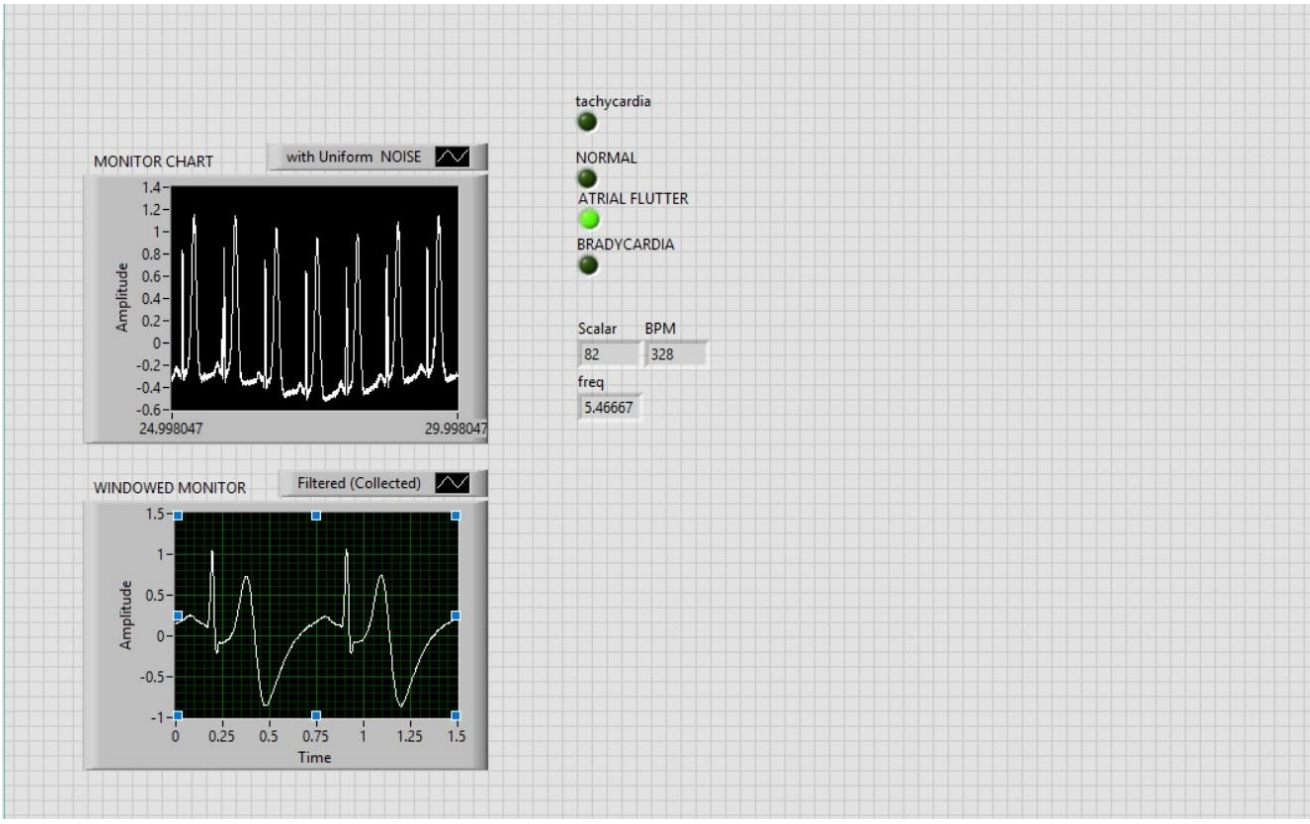

Figure 5.4

5.3 Surface Temperature Result:

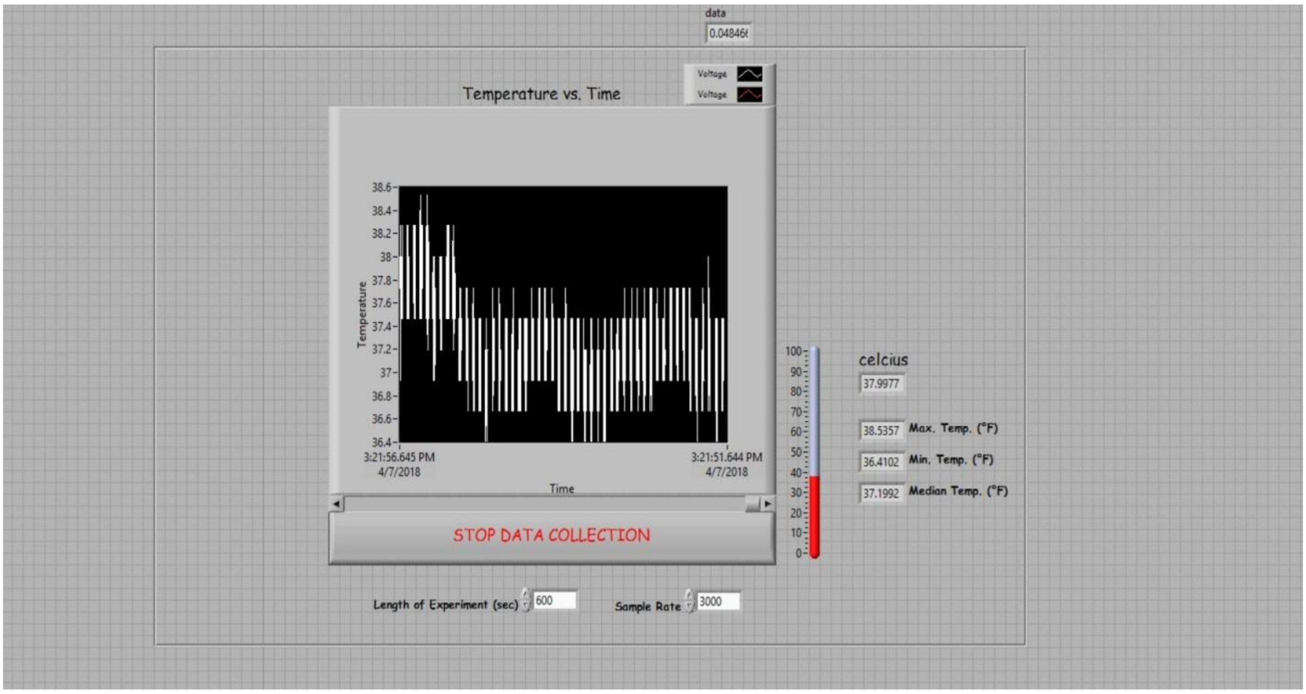

Figure 5.5

5.4 R wave detection result:

Figure 5.6

6. CONCLUSION AND FUTURE SCOPE

After being verified the Virtual Instruments, there still exists ample scope for the project to become a full-fledged standalone device. Sending data through web can also be done. Although internet may be available for web-publishing ; but in reality there may be no internet connectivity in ambulance and therefore there arises the need to use software's like TeamViewer to share screens along with mobile packet data used both at both the patient's and doctor's end. The testing of mobile packet data through suite software's available has to be carried out in future along with inclusion of other sensor's like Spirometer, Pulse Rate Oximeter, Digital Stethoscope, Heart Rate Monitor and Camera's (webcam) on both sides i.e., in ambulance and hospital so that the patient and doctor see each other can communicate especially for the doctor to personally provide hospitality. The psychological effect of this method does pacify most of them. The other most important implementation is to detect abnormalities in the signals acquired reducing the burden on the doctor! As biomedical engineers, having gained a thorough understanding of concepts, it would be more significant to carry out the diagnosis rather than just transmitting the acquired data. Therefore, future VI's would help detect abnormalities in the ECG signals, temperature fluctuations, etc., and warn the doctor before the patient reaches the hospital, so that the doctor is ready with the right treatment.

Apart from that, a GSM (Global System for Mobile Communications) module can also be interfaced which will send a SMS in a designed template stating or reporting the vital parameters. All of this would be stand-alone, installed in the ambulance. The VI's created have to be dumped onto a platform and along with sensors, DAQ card, processing circuit and GSM module, this would take the shape of a product which can be put to sale after rigorous testing in ambulances. So far, the main task of our team was to acquire data and in which we were successful!

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