



Labview based Electrocardiograph (ECG) Patient Monitoring System for Cardiovascular Patient using WSNs

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ABSTRACT

Lab VIEW and the signal processing-related toolkits can offer a tough and efficient environment and tools for resolving ECG signal processing problem. This paper prove how to use these advance powerful tools in de noising, analyzing, and extracting ECG signals easily and usefully not only in heart illness diagnosis but also in ECG signal processing research. Data is introduced from online data bank files, as Physic bank MIT-BIH data to the applications in this equipment for analysis. The proposed method arrangements with the study and analysis of ECG signal using biomedical toolkit effectively. In the first phase, ECG signal is acquired which is then monitored by filtering the raw ECG signal to remove undesirable noises. The next phase focuses on extracting the features from the acquired signal and at last picturing and analyzing the extraction of the signal results.

This paper helps to developing a Lab view based ECG patient monitoring system for cardiovascular patient using wireless sensor networks. The designed device has been divided into three parts. First part is ECG amplifier circuit, built using instrumentation amplifier followed by signal conditioning circuit with the operation amplifier Secondly, the ELVIS card is used to convert the analog signal into digital form for the further process. Furthermore, the data has been processed in Lab view where the digital filter systems have been applied to remove the noise from the developed signal. After processing, the algorithm was developed to calculate the heart rate and to study the arrhythmia condition. Finally, WSN technology has been added in our work to make device more communicative and much more cost-effective solution in telemedicine technology which has been key-problem to realize the tale diagnosis and monitoring of ECG signals. The technology also can be easily applied over already existing Internet.

Keywords

Wireless sensor network (WSN), Lab VIEW Biomedical Toolkit, Biomedical workbench, ECG, ECG Feature Extraction

1. INTRODUCTION

In current years, Electrocardiography (ECG) is the best usually used diagnostic tool in cardiology. It contributes considerably to the diagnostic and management of patients with cardiac disorders. Especially, it is essential to the diagnosis of cardiac arrhythmias and the serious myocardial ischemic syndromes .That's why it is critical to acquire accurate raw ECG signal caused by heart muscle, so that further signal processing can be performed with ease.

Biomedical signal monitoring is a very important tool used to understand physiological mechanisms of the body and to diagnostic problems, particularly, ECG signal which has most valuable clinical regarding information. An extensive range of human physiological conditions can be contingent from the PQRST parameters obtained from an ECG recording instrument [1]. Various Virtual Instrumentation approves the development and implementation of innovative and cost-effective in biomedical applications and gives information management solutions in different manner. As the healthcare system continues to process to the growing trends of care and capitation, it is vital for clinically useful and very cost-effective technologies to be implemented and utilized accordingly our requirements. As application needs will surely continue to change, virtual instrumentation systems will continue to offer users flexible and powerful solutions without using new equipment or outdated instruments. The Biomedical Workbench in Lab VIEW Biomedical Toolkit provides applications for bio signal and biomedical image analysis. These applications make possible to apply biomedical solution using National Instruments software, such as National Instruments Lab VIEW hardware. User can use these applications to screen and play bio signals, simulate and generate bio signals, evaluate bio signals, and view biomedical images [2]. User can acquire real world and real-time biomedical data by using biomedical sensors and National Instruments Lab VIEW hardware; also can import biomedical information from online data bank files, such Physio bank MIT-BIH database to the applications in this medical kit for analysis. National Instruments Lab VIEW hardware and the applications in this kit can also be used to generate standard analog biomedical signals to validate and test biomedical instruments [3] such as biomedical kit. The analysis and processing of bio signals and biomedical images kit can provide useful information for recognizing, imagining, and understanding biomedical features in human bodies and in animal bodies. The Lab VIEW Biomedical Toolkit includes tools that can be used to acquire, preprocess, remove, and analyze bio signals and medical images. By using the Biomedical Toolkit with National Instruments DAQ hardware, user can be set up a system for learning signal processing techniques in bioinstrumentation and also can be use different signal processing managements in research field and academic field projects related to biomedical engineering and other biomedical applications in various field [4].

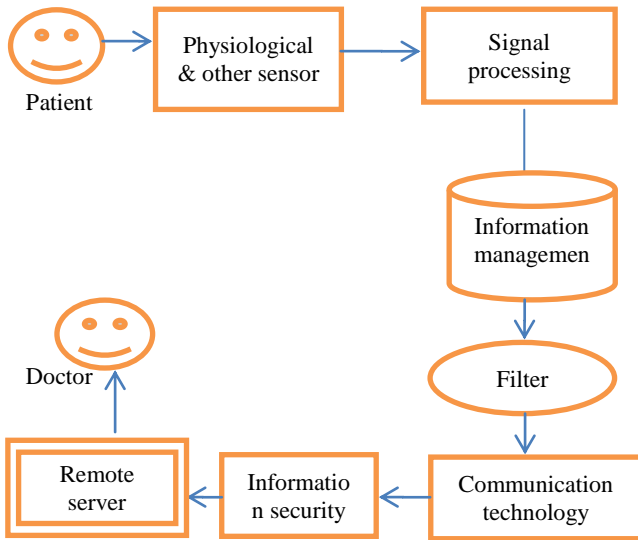


Figure 1 General Architecture of Remote Health Monitoring

2. BLOCK DIAGRAM OF PROPOSED ECG DEVICE

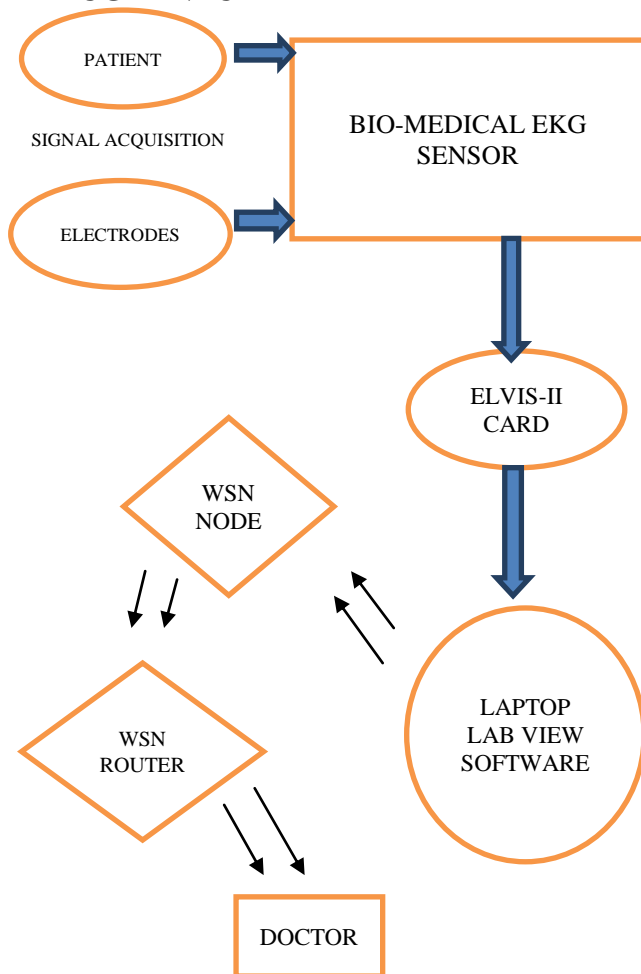


Figure 2 Proposed ECG Device system

The biomedical analysis process contains the following components

(a) **Front End Devices**, such as transducers and electrodes that user directly attach or connect to the subject. The front end might consist of preamplifiers and isolation circuits to guarantee the quality of the data acquisition.

(b) **National Instruments DAQ Hardware & ELVIS Hardware** that obtains data for analysis and processing. Various National Instruments DAQ hardware devices offer different specifications for sampling rate of system, resolution of the analog to digital converter and so on application.

(c) **Signal Processing in Lab view software** includes the Biomedical VIs and other signal processing tools in Lab VIEW. User can make customized VIs for processing bio signals and biomedical images and picture the analysis results in Lab VIEW software in bio medical kit.

(d) **Biomedical Workbench hardware tool kit** Ready-to-use applications for different acquired signal, preprocessing, extracting, and analyzing bio signals and biomedical images.

(e) **Actuator** Devices that transform electrical signals into certain kinds of motion or into physical signals. User can use the analog or digital output channels of NI DAQ hardware to drive an actuator.

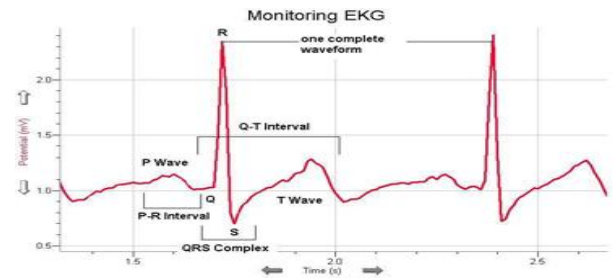


Figure 2 Typical ECG Signal

Normal Ranges for ECG Intervals (in Seconds)

Normal range	P-R interval	QRS interval	Rate	Q-T interval	S-T interval
Adults	0.18-20 S	0.07-0.10	60	0.33-0.43	0.14-0.16
Children (a)	0.15-0.18		70	0.31-0.41	0.13-0.15
			80	0.29-0.38	0.12-0.14
			90	0.28-0.36	0.11-0.13
			100	0.27-0.35	0.10-0.11
			120	0.25-0.32	0.06-0.07

Electrocardiography is used to calculate the rate and regularity of heartbeats, the presence of any damage to the heart, and the effects of medicines or devices used to control the heart used such as a pacemaker. Normally, the frequency range of Electrocardiography based signal may be 0.05 –100 Hz and its dynamic range in voltage is 1 – 10 mV. The Electrocardiography signal as shown in Figure 2 is characterized by five peaks and peaks labeled by the letters P, Q, R, S, and T. The performance of Electrocardiography system depends mainly on the accurate and reliable detection of the QRS system complex, as well as T- and P-waves in figure . The P-wave signifies the activation of the upper chambers of the heart, the atria, while the QRS complex and T-wave signify the

excitation of the ventricles or the lower chamber of the heart. The detection of the QRS complex is the most important job in automatic Electrocardiography signal analysis. Once the QRS complex has been recognized a additional detailed examination of Electrocardiography signal including the heart rate and the ST segment can be achieved [1, 2]. This research work offers the following helps to the produced system; foremost is the portable Electrocardiography monitoring platform based under the NI DAQ card & Elvis card .The Electrocardiography data was collected through the DAQ card to the PC or laptop and then transmitted to the end doctor (physician) through WSN to analyze the patient condition. In addition, the following example shows on how to calculate a person's heart rate based on an Electrocardiography and standard range shown in the table of different ranges for Electrocardiography intervals.

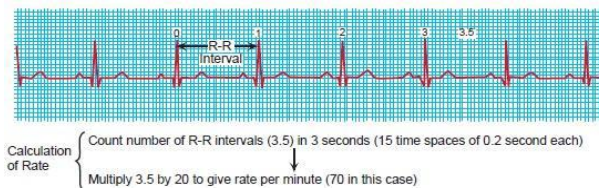


Figure 2.1 Calculation of Heart Rate

Calculation of a some body's heart with his ECG is based on the formula of $\text{Rate} = 60 \times \text{R-R Interval}$. R-R Interval is the amount of time in seconds between two R peaks. This formula was functional in determining the heart rate of a patient.

3. SYSTEM MODELING

Electrocardiograph signal is generated and analyzed on personal computer or laptop using software NI Lab VIEW 2 k 11 versions and Biomedical Workbench 2 k 13. Data is imported from online data bank files Physic bank MIT-BIH database which is loaded to system already.

NI Lab VIEW Biomedical Toolkit: Tools required for Biomedical Data Acquisition and Signal Processing

The National instrument Lab VIEW Biomedical Toolkit is a collection of ready to run applications, utilities, and algorithms designed to simplify the use of Lab VIEW software in physiological DAQ card, signal processing, and image processing. The toolkit includes applications commonly used in teaching physiology, Bio instrumentation, and biomedical signal processing and offers researchers with tools to create powerful custom Lab VIEW applications to accelerate their research. Ready-to-run applications include Bio signal Data logger and Player, File Viewer, Bio signal Generator, ECG Feature Extractor, Heart Rate Variability Analyzer, Non-invasive Blood Pressure Analyzer, 3-D Image Reconstruct or, and File Format Converter. The file conversion utility loads many common biomedical data logger formats into NI Technical Data Management Streaming (TDMS) format including various Biopac .ACQ, iWorx, .MAT, EDF, and HL7. Toolkit functions include signal processing procedures for common processing tasks on many bio signals such as EEG and ECG signal simulation, EEG bi spectral and coherence analysis, ECG feature extraction, and EMG power analysis etc.

The Biomedical Toolkit wants the Advanced Signal Processing Toolkit to also be installed on development machine in different manner. The Biomedical Workbench of NI Lab VIEW Biomedical Toolkit offers applications for bio

signal and biomedical image analysis. These applications can be used to log and play bio signals, simulate and generate bio signals, analyze bio signals, and view biomedical images. User can also add his own applications or Lab VIEW VI in Biomedical Work bench.

- (a) **Bio signal Rate Extractor VI** Detect cycles, spike periods, heart beats, and so on
- (b) **Bio signal Generation Express VI** Generate virtual bio signals or read bio signals from a file to send to a DAQ hardware device
- (c) **Read Image Express VI and Write Image Express VI**
 - Read and write RGB / RGB (alpha) .bmp, .jpeg, and . png files Read and write multi-frame DICOM images
 - Read and write DICOM tags with specified tag names, group, and IDs
 - Read images from DICOMDIR / IMGDIR Save multiple 2-D portions to an IMGDIR
- (d) **Read Bio signal Express VI and Write Bio signal Express VI** Read Plexon file & Read and write bio signal file.
- (e) **Electrocardiograph Feature Extractor VI**
 - Extract features with improved efficiency and accuracy of system
 - Extract ST segments in system
- (f) **Medical Image 2 Dimensional Viewer**
 - Render color images
 - Zoom, move, and drag 3 Dimensional image arrays
 - Automatically sense image orientation from DICOM tags

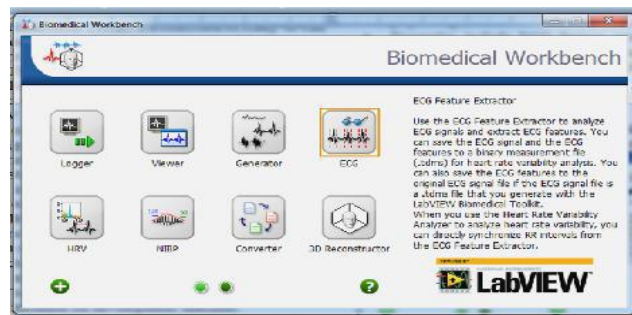


Figure 3 Biomedical Series Setup Lab view

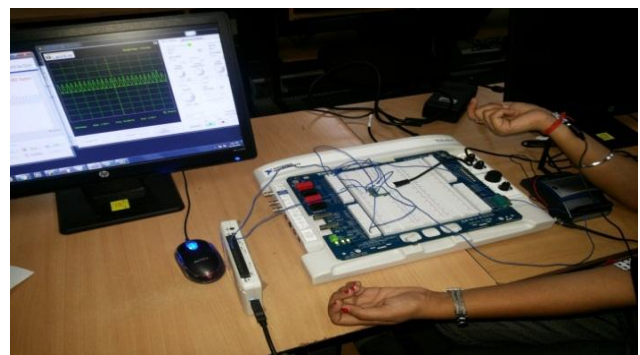


Figure 3.1 Biomedical ELVIS Setup

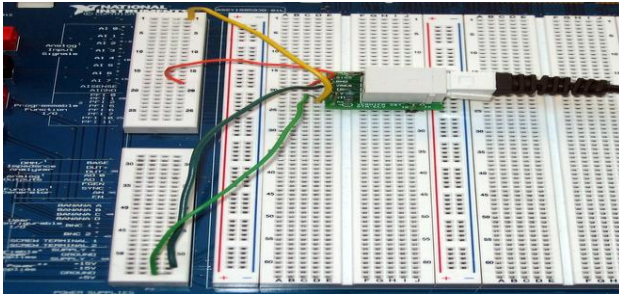


Figure 3.2 Connecting the Analog Proto Board Connector to NI ELVIS II Series

(g) Bio signals Simulation Express Vis Add 50 Hz or 60 Hz power line to a signal you create using the Bio signal Simulation VI Biomedical Workbench 2 k 13 includes services as:

- Full-featured, multichannel data logger for running bio signals to disk for playback and analysis .
- File conversion utility simplifies import / export of common physiological file formats.
- Examples include Electrocardiograph feature extraction, RR interval analysis, and 3 Dimensional image reconstruction
- Includes VI library with algorithms for EEG, EMG, Electrocardiograph, and more
- Customizable launcher allows addition of user-created applications and icons.
- Works seamlessly with NI educational platforms including NI ELVIS and most NI DAQ hardware products

(h) Surface Electrode

The principle of the electrodes is to convert a corporeal factor into an electrical output. The function of the transducer is to renew biological information into a quantifiable electrical signal. The transducer interface is provided using an electrode-electrolyte interface. The best preferable electrode is Ag/Ag cl, as it reduces the impedance while using it and the gel is used for the proper contact in between the surface of the skin and electrode.

4. DESIGNING STRATEGIES & INTERFACE WITH LAB VIEW

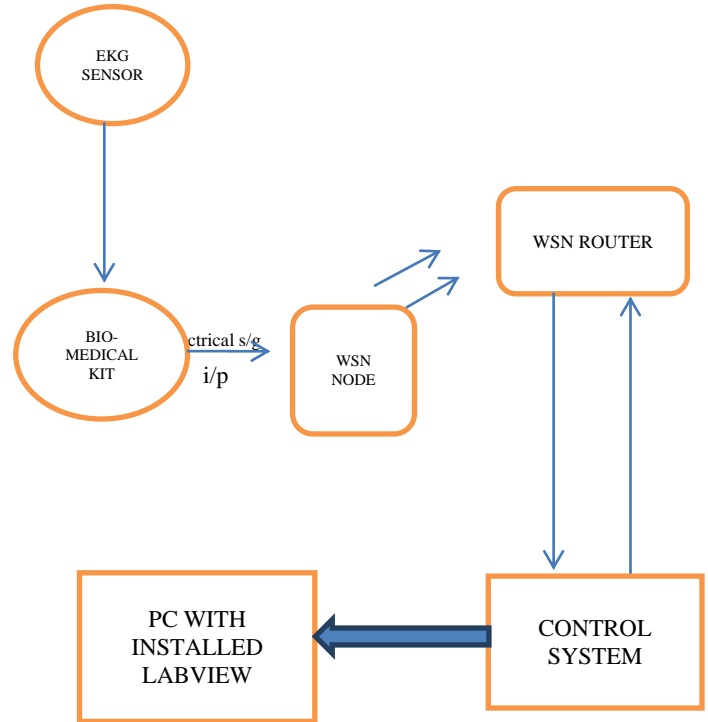


Figure 4 Block Diagram of Designing Strategies of Proposed System using LAB VIEW

The National Instrument Lab VIEW Biomedical Toolkit is a collection of ready to run applications, utilities, and algorithms designed to simplify the use of Lab VIEW software in physiological DAQ, ELVIS card, signal processing, and image processing. The toolkit includes applications commonly used in teaching physiology, bioinstrumentation, and biomedical signal processing and provides researchers with tools to create powerful custom Lab VIEW applications to accelerate their research. Ready-to-run applications include Bio signal Data logger and Player, File Viewer, Bio signal Generator, Electrocardiography Feature Extractor, Heart Rate Variability Analyzer, Non-invasive Blood Pressure Analyzer, 3 Dimensional Image Reconstruct or, and File Format Converter. The file conversion imports many common biomedical data logger formats into NI Technical Data Management Streaming (TDMS) format including Biopac .ACQ, iWorx, .MAT, EDF, and HL7. Toolkit functions include signal processing algorithms for common processing tasks on many bio signals such as EEG and ECG signal simulation, EEG spectral and coherence analysis, Electrocardiography feature extraction, and EMG power analysis.

The Biomedical bench Toolkit requires the Advanced Signal Processing Toolkit to also be installed on development machine. The Biomedical Workbench of National Instrument Lab VIEW Biomedical Toolkit provides applications for bio signal and biomedical image analysis. These applications can be used to log and play bio signals, simulate and generate bio signals, analyze bio signals, and view biomedical images. User can also add his own applications or Lab VIEW VI s in Biomedical Workbench.

5. RESULTS

The given system is based on the principle of heart rate monitoring system; it is able to produce the results shown in Figure 5, which show accurate Electrocardiography signals and

the correct calculation of both a resting and an raised up heart rate. Initially, there was an issue with the system regarding doctor notification subsystem which has been short by validating the proposed concept by running the VI at home, which sent both text and records Electrocardiography signal to our doctor notifying them that there was a detected problem with the patient's heart. It helps the freedom for the physician as well as the doctor to check up on patient's hearts from time to time by checking real-time waveforms as shown in Figure 5. The proposed device is well once all the hardware connected properly to meet the best criteria for the proposed idea our mind. As a complete system, it is very reliable and portable as well as cost effective.

(a) Generating Raw Electrocardiography Signals

User can also use different kinds of electrocardiographs to obtain electrocardiogram signals. The bandwidths of these electrocardiographs are not very high. National Instruments multichannel DAQ devices and ELVIS can be used to acquire raw Electrocardiography signals from the output terminals of Electrocardiography sensors. The sampling rates are typically to 125 Hz otherwise 250 Hz. User can store the acquired Electrocardiography signals in the NI TDMS file format for offline analysis. Online databases record such the MIT-BIH database also contains many typical Electrocardiography signals. The Biomedical Toolkit can load MIT-BIH Electrocardiography data directly using the palette VI or the Biomedical Workbench of system.

(b) Performance Feature Extraction on Electrocardiography Signals

For the purpose of conclusion, it is often need to extract various features from the preprocessed Electrocardiography data, including QRS intervals, QRS amplitudes, PR intervals, QT intervals, etc. These features offer information about the heart rate, the transmission velocity, the condition of tissues within the heart as well as various disorders. It supplies indication for the diagnoses of cardiac diseases. For this reason, it has drawn considerable attention in the Electrocardiography signal processing field. Lab VIEW Biomedical Toolkit offers an Electrocardiography Feature Extractor VI, and also an Electrocardiography Feature Extractor application for users to extract Electrocardiography features conveniently. User can select whether to detect QRS only or to detect all supported Electrocardiography features, including R position, R amplitude, iso level, QRS onset, QRS offset, P onset, P offset, T onset and T offset.

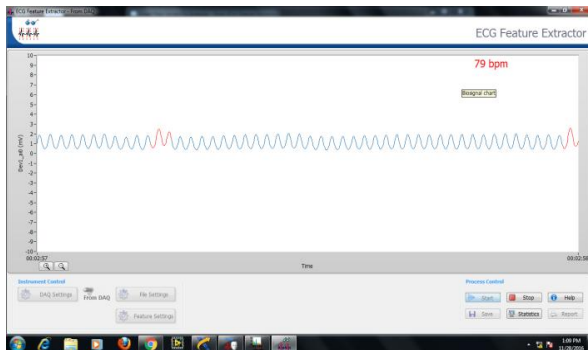


Figure 5 Generation of ECG Wave Form at TX Point Using WSNs

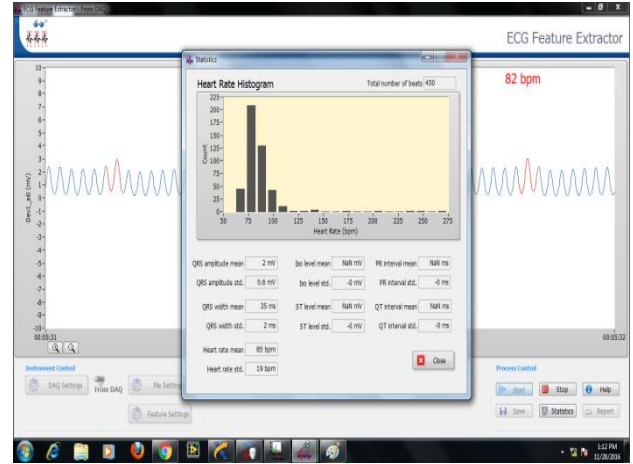


Figure 5.1 Heart Rate Histogram Statistics from Extracted Electrocardiography Experiment Window

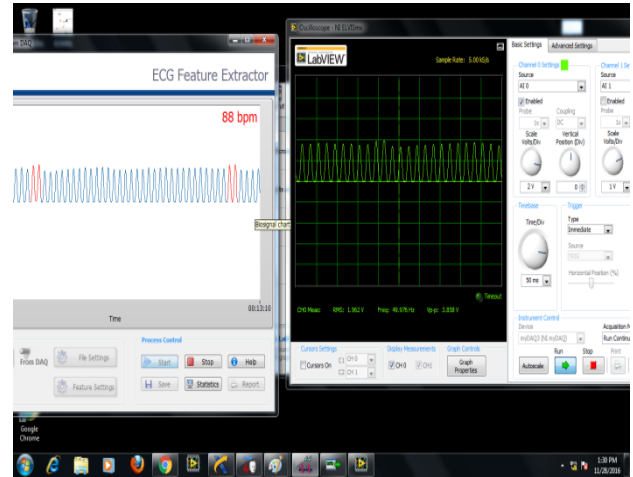
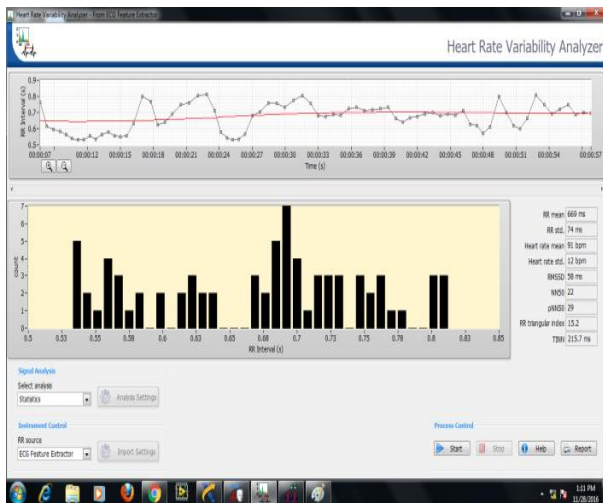


Figure 5.2 Same Electrocardiography Signal Generations at Rx Point Using WSNs

The Electrocardiography Feature Extractor firstly detects all beats i.e. R waves in the signal, and then extracts other features for every beat. Thus the accuracy of detecting R waves is very important [5].

For normal Electrocardiography signals, they can be easily detected, as shown in Figure 5. While abnormal morphology creates the detection difficult for Electrocardiography from patients with some particular heart disorder. Then sometimes it is desirable to complete some signal enhancement preprocessing before feature extraction of the signal then preprocessed Electrocardiography signal is used to identify position of R waves. After that, all other features will be extracted using original signal, because the signal enhancement may change these features. Signal enhancement usually holds two steps: filtering and rectification of signal .R waves of human Electrocardiography usually have a frequency between 10-25 Hz. Thus R waves can be more clear and easy for detection after filtering using a band pass filter. Rectification sometimes can further enhance the R waves to make them easier to detect. Absolute and square are two common used rectification methods. If processing result of an Electrocardiography signal with particular negative R waves and large T waves. It can be seen that, after enhancement, all beats can be easily noticed. Bio signal Filtering VI is used to

filter the signal. In Electrocardiography Feature Extractor application, a preprocessing settings window is provided for users to perform the signal enhancement interactively.



Total number of beats:	2249
Heart rate mean	76 bpm
Heart rate std.	5.1 bpm
QRS width mean	70 ms
QRS width std.	7.2 ms
QRS amplitude mean	1.5 mV
QRS amplitude std.	0.11 mV
PR interval mean	151 ms
PR interval std.	5.02 ms
QT interval mean	390 ms
QT interval std.	46.2 ms
Iso level mean	-0.36 mV
Iso level std.	0.053 mV
ST level mean	-0.027 mV
ST level std.	0.051 mV

Figure 5.3 Complete Heart Rate Statistics Report from Extracted Electrocardiography Report Using Biomedical kit

After take out the features, user can perform heart rate variability analysis on the R-R interval signal to establish the state of the heart and nerve system. In heart rate variability Analyzer of Lab VIEW Biomedical Toolkit, user can directly synchronize the RR intervals from Electrocardiography Feature Extractor. [7] Thus process of Electrocardiography feature extractor includes 4 steps:

- i. Acquire Electrocardiography signal from DAQ or read from file.
- ii. Preprocess Electrocardiography signal, including filtering and rectification.
- iii. Extract features.
- iv. (Optional) Visualize and analyze the extraction results.

6. CONCLUSION

The modern analysis techniques available on the computer are becoming precious to the practicing physician as well as researchers. The diagnostic decision will be more accurate. Peak detection in electrocardiogram is one of the solved problems using Lab VIEW. Clinical applications and research studies both apply heart rate variability analysis results for statistical and frequency methods. Thus the developed system can be very useful to expect the heart abnormalities of a

person, even before preliminary investigations. The technique is user-friendly, low cost and hence anyone septic of heart problem can analyze Electrocardiography using this efficient method.

In this paper, the low-cost biomedical measurement with help of system with the capability of storage in digital format as well as transmitting the data to the remote area has been presented. The hardware implementations using commercially available devices and the software written in Lab view program for continuously monitoring Electrocardiography data have been described. The proposed measurement system is also capable of sending the data through wireless sensor networks to the physician or health care center with no time. The proposed system could be modified by increasing the number of channels and improves the cover distance between patient to doctor.

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