Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 8, pp.5603-5607, August, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

ECG FEATURE EXTRACTION USING NI LAB-VIEW BIOMEDICAL WORKBENCH

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ARTICLE INFO

Article History:

Received 2nd, July, 2015
Received in revised form 10th, July, 2015
Accepted 4th, August, 2015
Published online 28th, August, 2015

Key words:

NI LabVIEW Biomedical Toolkit Biomedical workbench, ECG, ECG parameters ECG Feature Extraction

ABSTRACT

LabVIEW and the signal processing-related toolkits can provide a robust and efficient environment and tools for resolving ECG signal processing problem. This paper demonstrate how to use these advance powerful tools in denoising, analyzing, and extracting ECG signals easily and conveniently not only in heart illness diagnosis but also in ECG signal processing research. Data is imported from online data bank files, such as Physio bank MIT-BIH database to the applications in this kit for analysis.
The proposed method deals with the study and analysis of ECG signal using LabVIEW Biomedical toolkit effectively. In the first phase, ECG signal is acquired which is then followed by filtering the raw ECG signal to remove unwanted noises. The next phase focuses on extracting the features from the acquired signal and at last visualizing and analyzing the extraction results.

INTRODUCTION

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

Biomedical signal monitoring is an important tool used to understand physiological workings of the body and to diagnose potential problems, particularly, ECG signal which has valuable clinical information. An extensive range of human physiological conditions can be inferred from the PQRST parameters obtained from an ECG recording instrument [1].

Virtual Instrumentation allows the development and implementation of innovative and cost-effective biomedical applications and information management solutions. As the healthcare industry continues to respond to the growing trends of managed care and capitation, it is imperative for clinically useful, cost-effective technologies to be developed and utilized. As application needs will surely continue to change, virtual instrumentation systems will continue to offer users flexible and powerful solutions without requiring new equipment or traditional instruments.

The Biomedical Workbench in LabVIEW Biomedical Toolkit provides applications for biosignal and biomedical image analysis. These applications make possible to apply biomedical solution using National Instruments software, such as LabVIEW with National Instruments hardware. User can use these applications to screen and play biosignals, simulate and generate biosignals, evaluate biosignals, and view biomedical imagery [2]. User can acquire real world and real-time biomedical data by using biomedical sensors and National Instruments hardware; also can import biomedical information from online data bank files, such as Physio bank MIT-BIH database to the applications in this kit for analysis. National Instruments hardware and the applications in this kit can also be use to generate standard analog biomedical signals to validate and test biomedical instruments [3].

The analysis and processing of biosignals and biomedical images can provide useful information for recognizing, visualizing, and understanding biomedical characteristics in human bodies and in animal bodies. The Lab VIEW Biomedical Toolkit includes tools that can be use to acquire,

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preprocess, extract, and analyze biosignals and biomedical images.

By using the Biomedical Toolkit with National Instruments DAQ hardware, user can set up a system for learning signal processing techniques in bioinstrumentation and also can use different signal processing methods in research and academic projects related to biomedical engineering and other biomedical fields [4].

1.1Biomedical Analysis Process

The following figure demonstrates the biomedical analysis process that uses the Biomedical Toolkit with National Instruments DAQ hardware.

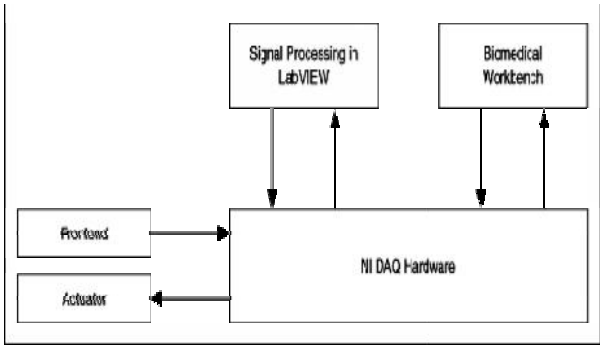


Figure 1

The biomedical analysis process contains the following components:

- ***Front End***—Devices, such as transducers and electrodes that user directly attach or connect to the test subject. The front end might include preamplifiers and isolation circuits to ensure the quality of the data acquisition.
- ***National Instruments DAQ Hardware***—Hardware that acquires data for analysis and processing. Different National Instruments DAQ hardware devices provide different specifications for sampling rate, resolution of the A/D converter (ADC), and so on.
- ***Signal Processing in Labview***—Includes the Biomedical VIs and other signal processing tools in Lab VIEW. User can create customized VIs for processing biosignals and biomedical images and visualize the analysis results in Lab VIEW.
- ***Biomedical Workbench***—Ready-to-use applications for acquiring, preprocessing, extracting, and analyzing biosignals and biomedical images.
- ***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 National Instruments DAQ hardware to drive an actuator.

MATERIAL AND METHOD

ECG signal is generated and analysed on personal computer using software NI Lab VIEW (2011evaluation version) and Biomedical Workbench-2013.Data is imported from online data bank files Physio bank MIT-BIH database

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

The NI 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, 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 Biosignal Data logger and Player, File Viewer, Biosignal Generator, ECG Feature Extractor, Heart Rate Variability Analyzer, Non-invasive Blood Pressure Analyzer, 3D Image Reconstructor, and File Format Converter. The file conversion utility 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 biosignals such as EEG and ECG signal simulation, EEG bispectral and coherence analysis, ECG feature extraction, and EMG power analysis.

The Biomedical Toolkit requires the Advanced Signal Processing Toolkit to also be installed on development machine.

The Biomedical Workbench of NI Lab VIEW Biomedical Toolkit provides applications for biosignal and biomedical image analysis. These applications can be use to log and play biosignals, simulate and generate biosignals, analyze biosignals, and view biomedical images. User can also add his own applications or Lab VIEW VIs in Biomedical Workbench.

New Features and Changes

The 2013 release of the Biomedical Toolkit includes two new VIs:

Biosignal Rate Extractor VI

Detect cycles, spike periods, heart beats, and so on

Biosignal Generation Express VI

Generate virtual biosignals or read biosignals from a file to send to a DAQ device

The 2013 release of the Biomedical Toolkit includes the following changes:

RT Target Support

Use the Biomedical VIs on Lab VIEW RT targets

The Biomedical File I/O Express VIs and the Medical Image Processing VIs do not support real-time applications.

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 2D slices to an IMGDIR

Read Biosignal Express VI and Write Biosignal Express VI

- Read Plexon files
- Read and write biosignal file annotations

ECG Feature Extractor VI

- Extract features with improved efficiency and accuracy
- Extract ST segments

Medical Image 2D Viewer

- Render colour images
- Zoom, move, and drag 3D image arrays
- Automatically detect image orientation from DICOM tags

Biosignal Simulation Express VIs

Add 50 Hz or 60 Hz power line noise to a signal you create using the Biosignal Simulation Express VI
Biomedical Workbench -2013 includes facilities as:

- Full-featured, multichannel data logger for streaming biosignals to disk for playback and analysis
- File conversion utility simplifies import/export of common physiological file formats
- Examples include ECG feature extraction, RR interval analysis, and 3D image reconstruction
- Includes VI library with algorithms for EEG, EMG, ECG, 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 products

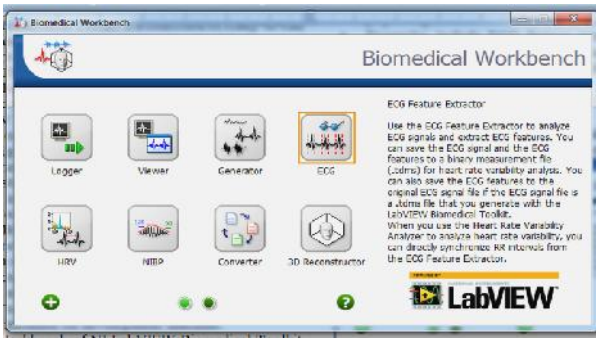


Figure 2

Acquiring Raw ECG Signals

User can use various kinds of electrocardiographs to acquire electrocardiogram (ECG) signals. The bandwidths of these electrocardiographs are not very high. National Instruments multichannel DAQ devices can be used to acquire raw ECG signals from the output terminals of ECG sensors. The sampling rates are typically 125 Hz or 250 Hz. User can store the acquired ECG signals in the NI TDMS file format for offline analysis. Online databases such as the MIT-BIH database also contain many typical ECG signals. The Biomedical Toolkit can import MIT-BIH ECG data directly using the palette VIs or the Biomedical Workbench.

Performing Feature Extraction on ECG Signals

For the purpose of diagnosis, it is often need to extract various features from the preprocessed ECG data, including QRS intervals, QRS amplitudes, PR intervals, QT intervals, etc. These features provide information about the heart rate, the conduction velocity, the condition of tissues within the heart as well as various abnormalities. It supplies evidence for the diagnoses of cardiac diseases. For this reason, it has drawn considerable attention in the ECG signal processing field.

Lab VIEW Biomedical Toolkit provides an ECG Feature Extractor VI, and also an ECG Feature Extractor application for users to extract ECG features conveniently. User can select whether to detect QRS only or to detect all supported ECG features, including R position, R amplitude, iso level, QRS onset, QRS offset, P onset, P offset, T onset and T offset.

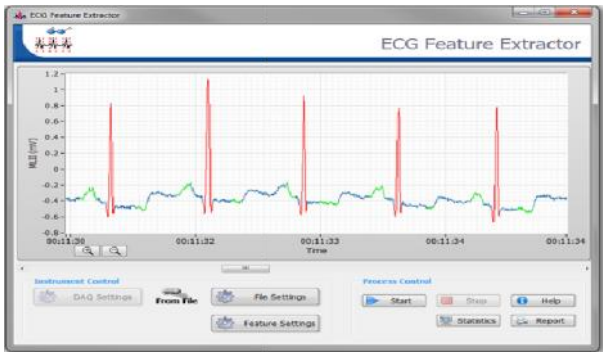


Figure 3 ECG multiresolution analysis and implementation of QRS detection

The ECG Feature Extractor firstly detects all beats (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 ECG signals, they can be easily detected, as shown in Figure 3. While abnormal morphology makes the detection difficult for ECG from patients with some specific heart diseases. Thus sometimes it is needed to perform some signal enhancement (preprocessing) before feature extraction. The preprocessed ECG signal is used to detect 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 contains two steps: filtering and rectification. R waves of human ECG usually have a frequency between 10-25Hz. Thus R waves can be more obvious and easy

for detection after filtering using a bandpass filter. Rectification sometimes can further enhance the R waves to make them easier to detect. Absolute and square are two common used rectification methods. Figure 4 shows the processing result of an ECG signal with some negative R waves and very large T waves. It can be seen that, after enhancement, all beats can be easily detected. Biosignal Filtering VI is used to filter the signal. In ECG Feature Extractor application, a preprocessing settings window is provided for users to perform the signal enhancement interactively.

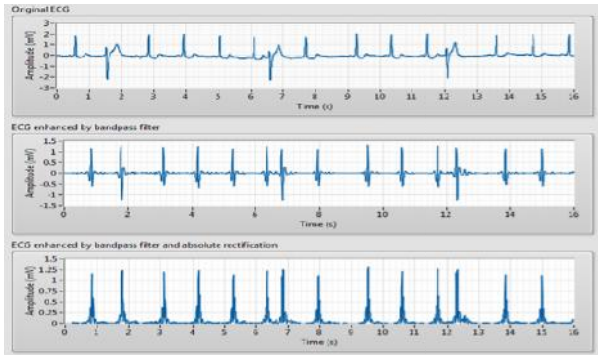


Figure 5 Original ECG, ECG after MRA and ECG after peak/valley detection [6**]**

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

1. Acquire ECG signal from DAQ or read from file.
2. Preprocess ECG signal, including filtering and rectification.
3. Extract features.
4. (Optional) Visualize and analyze the extraction results.

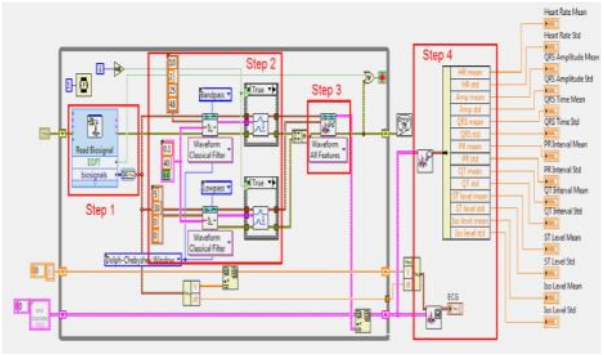


Figure 6

RESULT

Using LabView-2011 and Biomedical Toolkit 2013 evaluation version software, ECG features are extracted for data files imported from online data bank files, such as Physio bank MIT-BIH database. Before extraction files must be converted in .tdms format using File converter in Biomedical workbench. A sample result for 100.tdms file is mention here;

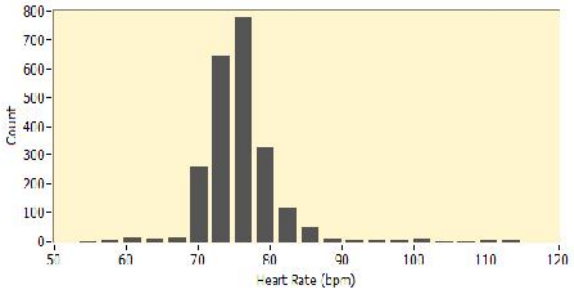
ECG Feature Extractor Report

File Name: C:\Program Files\National Instruments\Biomedical Toolkit\Workbench\samples\100.tdms

Channel Name: MLII Report Time: 05/07/2015 10:23:34 PM User Name: Admin General

Start time	00:00:11.6
End time	00:30:05.5
Preprocessing	Filtering (10~25Hz)
QR interval	Middle
RS interval	Middle
PR interval	Middle
QT interval	Middle

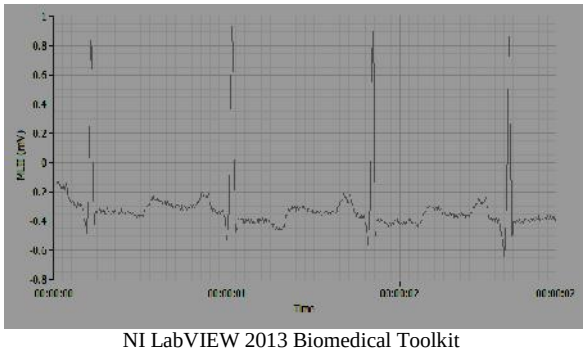
Heart Rate Histogram



Statistics

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

Current Waveform



NI LabVIEW 2013 Biomedical Toolkit

CONCLUSION

The advanced analysis techniques available on the computer are becoming invaluable to the practicing physician as well as researchers. The diagnostic decision will be more accurate. Peak detection in electrocardiogram (ECG) 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 predict the heart abnormalities of a person, even before preliminary investigations. The technique is user-friendly, low cost and hence anyone sceptic of heart problem can analyze ECG using this efficient method.

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How to cite this article:

Anjali Deshmukh and Yogendra Gandole., ECG Feature Extraction Using Ni Lab-View Biomedical Workbench. *International Journal of Recent Scientific Research Vol. 6, Issue, 8, pp.5603-5607, August, 2015*

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