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Acquiring Ecg Signals And Analysing For Different Heart Ailments

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Abstract
This paper describes and focuses on acquiring and identification of cardiac diseases using ECG waveform in LabVIEW software, which would bridge the gap between engineers and medical physicians. This model work collects the waveform of an affected person. The waveform is analyzed for diseases and then a report is sent to the doctor through mail. Initially the waveforms are collected from the person using EKG sensor with the help of surface electrodes and the hardware controlled by MCU C8051, acquires ECG and also Phonocardiogram (PCG) synchronously and the waveform is sent to the PC installed with LabVIEW software through DAQ-6211. The waveform in digital format is saved and sent to the loops containing conditions for different diseases. If the waveform parameters coincide with any of the looping statements, particular disease is indicated. Simultaneously the patient PCG report is also collected in a separate database containing all information, which will be sent to the doctor through mail.
Index Terms: ECG (Electrocardiogram), LABVIEW software, Microcontroller Unit (MCU) C8051, Data Acquisition Card.

I. INTRODUCTION

The heart is divided into four chambers. The upper chambers are called atria while the lower chambers are called ventricles. Blood is squeezed by heart muscle from chamber to chamber. During the squeezing process, valves keep blood flowing as smoothly as possible into the heart and out to the body by automatically opening to let blood in from chamber to chamber and closing to prevent blood backflow. Heart sounds, the composite sound produced by myocardial systolic and diastolic, hoist valve, blood flow and cardiovascular vibration impact, contain a great deal of physiological and pathological information regarding human heart and vascular.

These days cardiac diseases are found to be very common among people. In order to find out these diseases a general method of measuring heart rate, ECG waveform is used. Electrocardiography(ECG) is a transthoracic (across the chest) interpretation of the electrical activity of the heart over a period of time, as detected by the electrodes attached to the outer surface of the skin and recorded by a device external to the body. The recording produced by this non-invasive procedure is termed as **electrocardiogram (**also ECG or EKG). The measurement of ECG waveform is still done using traditional method of 12-Lead electrode system. In order to overcome the complexity in measuring the ECG waveform, we implement a system containing 3-lead electrode system to find a certain amount of diseases. These waveforms arise due to change in potentials on the surface of the heart. ECG is used to measure the rate and regularity of heartbeats as well as the size and position of the chambers. The presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart (such as a pacemaker) is also detected by the ECG. The output of ECG is generally recorded in a graph with time on X-axis and voltage in Y-axis. But in our work the waveform is obtained in real time and made to run lively and stored for future references.

II. SYSTEM DESCRIPTION

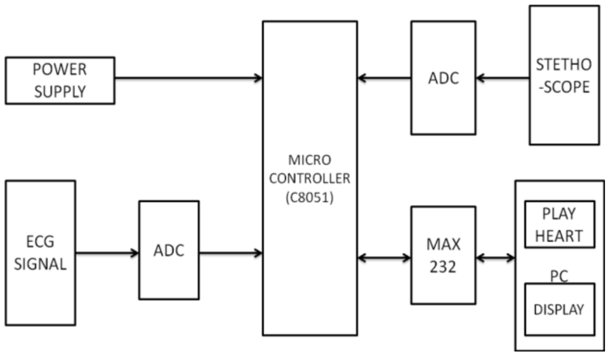


Fig 1 Hardware system diagram

As shown in Fig.1, heart sounds and ECG are the data collected in parallel using sensors. These signals collected by sensors are filtered and amplified by a signal conditioning circuit and then converted into digital signal by using ADC. Theses digital signals are then sent to the PC through USB. In this way, the ECG waveform can be shown on the screen. At the same time, the heart sounds are also played. The quality of acquisition of heart sounds is easily affected by the patients, the heart sounds are played by using headphone and not by using speakers. The headphone for auscultation must be selected carefully, it is required to wear comfortably and exclude external noise. In this paper monitor headphone is used and recommended.

Previously the waveforms for different types of diseases were specified and given as conditional statements (as data's given by medical books). Each disease has certain specific characteristics. Depending upon the conditions mentioned, the corresponding conditional statements are given. This real time waveform acquired, is passed into the conditional statements, where each statement (condition) is checked and thus if any condition is comparatively satisfied with the real time waveform taken from the patient, the disease is identified. Therefore the identified disease is reported through mail to the consulting physician, which saves lot of time and cost.

A. Signal Acquisition

PCG sensor is made of eight auscultation-level standards stethoscope OSMed130K and capacitor microphone. OSMed130K have double-faced chest piece, with one side diaphragm-shaped and the other bell-shaped, and could be rotated 180^o for interactive use. Bell type chest piece acquires some minor vascular murmur or low-frequency sounds, and diaphragm type chest piece is used for collecting most of the other voices. Capacitor microphones (frequency response of 20 to 20 kHz, sensitivity 15mv/Pa) can perfectly reflect the heart sounds and noise. The heart sound is mechanically amplified by Stethoscope firstly, transferred from capacitor microphone into a voltage signal which is filtered and amplified by conditioner. Because the sensor output signal is relatively weak and difficult to extract useful information directly, the preamplifier circuit is used to enlarge it about ten times firstly. But the signal includes much low-frequency noise (friction sound, breathing sound, the human interference signal, and offset drift of the preamplifier, etc.), which would lead to heart sound signals to be interrupted.

EKG SENSOR

The EKG sensor measures electrical signals produced during muscle contractions. The EKG sensor measures cardiac electrical potential waveforms (voltages produced during the contraction of the heart). It can be used to make standard 3-lead EKG tracings to record electrical activity in the heart, or to collect surface EMG recordings to study contractions in muscles in your arm, leg or jaw. Each of the three leads on the EKG sensor connects to a disposable electrode. A package of 100 disposable electrodes is included with the sensor. This is a replacement package of 100 electrodes for use with the EKG sensor.

SPECIFICATIONS:
Offset: ~1.00V(+-0.3 V)
Gain: 1mV body potential/ 1V sensor Output

DAQ-6211

The National Instruments USB-6211 is a bus-powered USB M series multifunction data acquisition (DAQ) module optimized for superior accuracy at fast sampling rates. It offers 16 analog inputs; 250 kS/s single channel sampling rate; two analog outputs; four digital input lines; four digital output lines; four programmable input ranges(+_0. 2 to +_ 10V) per channel; digital triggering; and two counter /timers. The NI USB-6211 is designed specifically for mobile or space-constrained applications. Plug-and-play installation minimizes configuration and setup time, while direct screw-terminal connectivity keeps costs down and simplifies signal connections. This product does not require external power. This mobile also features the new NI signal streaming technology, which gives you DMA-like bidirectional high-speed streaming of data across the USB bus.

Driver Software

NI-DAQmx driver and measurement services software provides easy-to-use configuration and programming interfaces with features such as DAQ Assistant to help reduce development time. M series devices are not compatible with the Traditional NI-DAQ (Legacy) driver.

Application Software

Every M series data acquisition device includes a copy of NI LabVIEW SignalExpress LE data-logging software, so you can quickly acquire, analyze, and present data without programming. In addition to LabVIEW SignalExpress, M series data acquisition devices are compatible with the following versions(or later) of NI application software-LabVIEW 7.1, Lab Windows/CVI 7.x, or Measurement Studio 7.x and LabVIEW 10.1. M Series data acquisition devices are also compatible with Visual Studio .NET, C/C++, and Visual Basic 6.

III. SYNCHRONOUS ACQUISITION AND REAL-TIME PLAYBACK SOFTWARE

A. *Synchronous Acquisition Implementation*

The spectrogram of human ECG is about from 0.05 to 100Hz, the major components of human PCG are below 500Hz, and the murmur is below 1500Hz. According to the sampling theorem, that is, the sampling frequency (f_s) must be twice greater than the cut-off frequency (f_c) of the signal. Considering the requirements of delay in playing heart sounds the sampling rate of (8000Hz, 11025Hz,22050Hz, or 44100Hz), 400Hz for ECG sampling and 8000Hz for heart sounds sampling are introduced in the system.

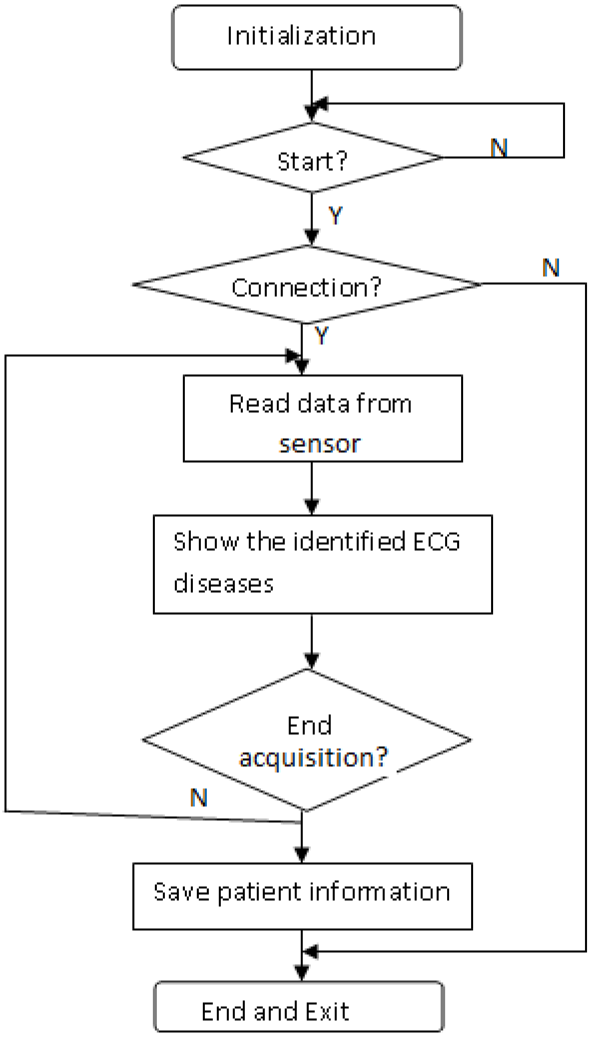
16-bit ADC is used for PCG, and 10-bit ADC is used for ECG. In order to achieve synchronous transmission, ECG data is converted into 16-bit in MCU. Two hundred PCG data, 10 ECG data, header and parity will compose of a package data as a unit. Data format is shown in Fig:2

Header	PCG	ECG	Parity

Fig 2 Data packet format

The communication between MCU and host uses USB. In the program, resource is set using the attribute nodes, including baud rate, bits per sample, parity, stop bit, flow control and so on. 'VISA open', 'VISA close', 'VISA write' and 'VISA read' functions are used to complete communication.

In 'Acquisition.vi' programmed on LabVIEW, all kinds of variables such as PCG data file and ECG data file for temporary save, and selection of auscultation area should be initialized. There are five traditional areas, mitral valve area, pulmonary area, aortic area, secondary aortic area and tricuspid area. Because the influence of valve place and sound transmission, other right area could also be chosen, usually the loudest Area should be chosen. When user click 'Acquisition' button on front panel, send start acquisition instruction, read data package and separate into PCG and ECG, show on front panel and play heart sounds and heart diseases simultaneously. While stop instruction, close USB, input patient information and save it, delete the temporary files, close progress, exit. Flow chart is shown in Fig.3.



IV. LABVIEW SOFTWARE

LabVIEW is a comprehensive development environment that provides engineers and scientists unprecedented hardware integration and wide-range compatibility. LabVIEW inspires you to create and develop measurement and control systems. NI LabVIEW is a powerful, industry-standard graphical development environment. Academic campuses worldwide use of labVIEW to deliver project-based learning. LabVIEW offers unrivaled integration with thousands of hardware devices and provides hundreds of built-in libraries for advanced analysis and data visualization. With the intuitive nature of the graphical programming environment, student can:

1. Visualize and explore theoretical concepts through interactive simulations and real-world signals
2. Design projects in applications such as measurement, control, embedded, signal processing, and communication
3. Compute, simulate, and devise solutions to homework problems

LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs/subroutines are called virtual instruments (Vis). Each VI has three components: a block diagram, a front panel and a connector panel. The last is used to represent the VI in the block diagrams of other, calling VI s. Controls and indicators on the front panel allow an operator to input data into or extract data from a running virtual instrument.

However, the front panel can also serve as a programmatic interface. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector panel. This implies each VI can be easily tested before being embedded as a subroutine into a larger program. The graphical approach also allows non-programmers to build programs by dragging and dropping virtual representations of lab equipment with which they are already familiar. The LabVIEW programming environment, with the included examples and documentation, makes it simple to create small applications. This is a benefit on one side, but there is also a certain danger of underestimating the expertise needed for high-quality G programming. For complex algorithms or large-scale code, it is important that the programmer posses an extensive knowledge of the special LabVIEW syntax and the topology of its memory management. The most advanced LabVIEW development systems offer the possibility of building stand-alone applications. Furthermore, it is possible to create distributed applications, which communicate by a client/server scheme, and are therefore easier to implement due to the inherently parallel nature of G.

V. DISEASES CLASSIFICATION

Each heart disease has some specific characteristics in its ECG waveform response, that is each disorder has corresponding alteration or change in its amplitude level or time interval. These conditions are mentioned in stack sequence, a single sample is selected and condition is mentioned, therefore the corresponding disease is detected. For our model we have taken four diseases.

PROLONGED PR INTERVAL
1. No less than 0.12s
2. No more than 0.2s

LEFT VENTRICULAR HYPERTROPHY
1. The R-wave in V5 or V6 exceeds 25mm
2. The S-wave in V1 or V2 exceeds 25mm
3. The total value of the R-wave in V5 or V6 plus The S-wave inV1 or V2 exceeds 35mm
4. T-wave inversion

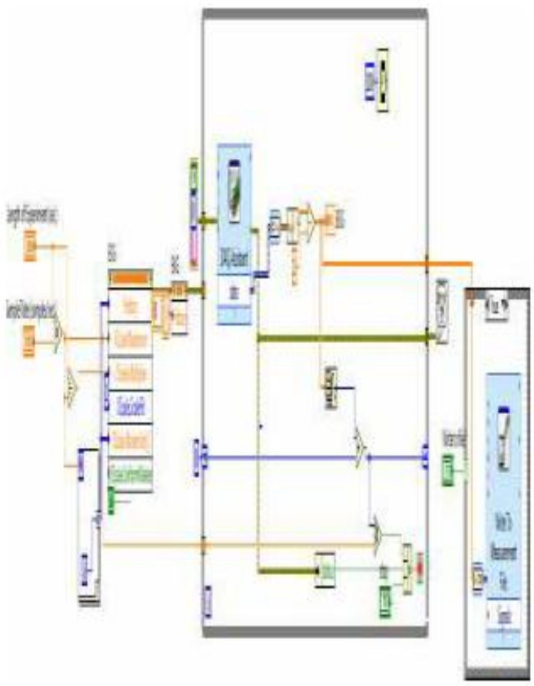
RIGHT ATRIAL ENLARGEMENT
1. P-wave height exceeds 2.5mm

LEFT ATRIAL ENLARGEMENT
1. P-wave width exceeds 0.08s

VI. REMOTE MONITORING

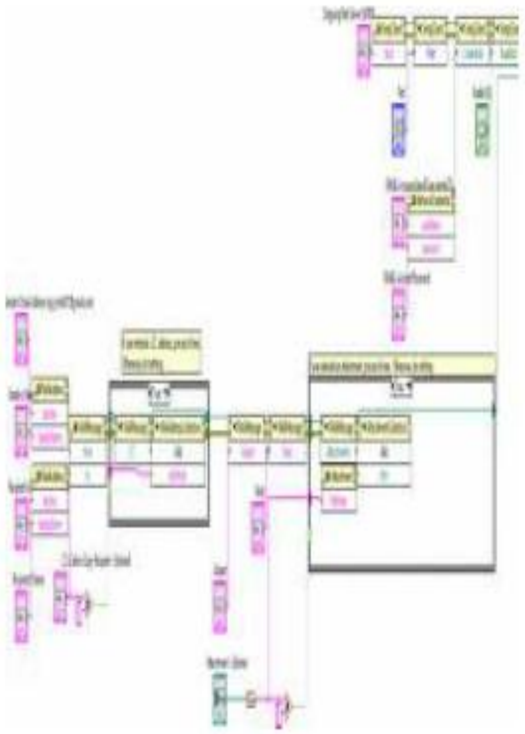
Wireless technology has many potential benefits for remote monitoring applications. However, it is rare to see adoption in industry because of the complexities of programming and deploying a reliable, secure, and high-performance wireless system. NI Wi-Fi data acquisition (DAQ) devices meet these challenges by combining IEEE 802.11 wireless or Ethernet communication, direct sensor connectivity, and the flexibility of NI LabVIEW software.

VII. BLOCK DIAGRAM



- Initially the sampling rate and length of the waveform is given through numeric controls.
- Both of the parameters are manipulated using for loop and given to EKG generation part in the program.
- After this the control is given to the execution control While loop for initializing DAQ on the input part.
- Further option of writing (storing) the obtained waveform is given through Boolean options.
- The next block of diseases specifications is given using stacked sequence structure.

- Each case in the stack contains Conditional statements for the diseases.



- In the remote monitoring part, the sender and receiver e-mail addresses are given initially, along with both of their names.
- Then the body of the mail that is what message has to be mailed is given.
- At the same time when the sender gives his account password, only the process of sending is enabled.
- Any attachments have to be sent in the mail can be done by enabling the Boolean option.

VIII. RESULTS AND CONCLUSION

The objective of the present work is to develop a comprehensive system which can acquire and analyze ECG signals for identifying different cardiac ailments of a person, has been achieved. The developed system includes microcontroller based data acquisition and signal conditioning system which can acquire ECG signals (few milli volts) of a person and sends it to LabVIEW. In LabVIEW an algorithm is developed using LabVIEW biomedical tool kit to extract the required features out of the acquired ECG signal for diagnosis of abnormalities present in particular person's ECG.

For the standardization of the developed system, ECG of normal persons have been measured and compared with that of the standard ECG values. The system is calibrated accordingly. The measured ECG signal characteristics are tested for different persons and the results are discussed below.

Standard ECG is represented in fig1. And respective ECG characteristics are tabulated in Table-1:

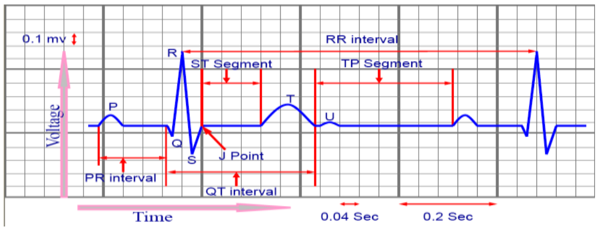


Fig.1. Standard ECG waveform

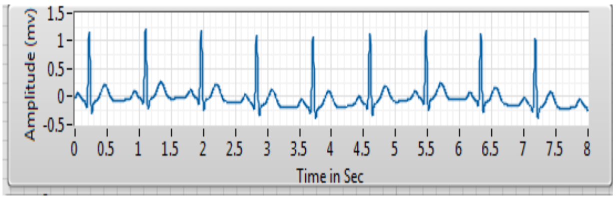
PR Interval	QRS Interval	QT Interval	RR Interval
0.12 to 0.20sec	0.08 to 0.10sec	0.4 to 0.43sec	0.6 to 1.0sec

Table.1. Standard ECG characteristics

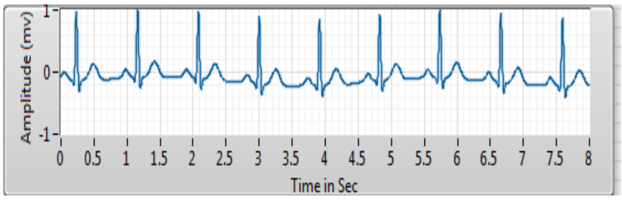
After calibration, the ECG of different persons (subject) is recorded as follows and the characteristics of respective ECGs are consolidated in Table2.

Operated conditions: 60Hz frequency, Sampling rate: 512Hz

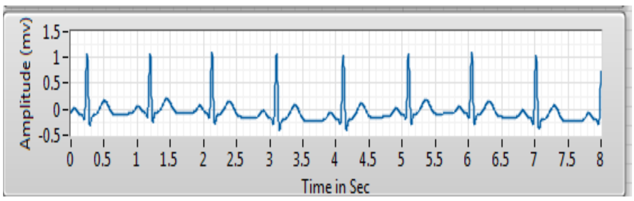
Subject – 1 Heart Rate: 60bpm Diagnosis: Normal



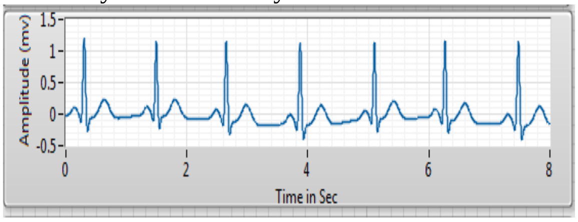
Subject – 2 Heart Rate: 65bpm Diagnosis: Normal



Subject – 3 Heart Rate: 70bpm Diagnosis: Normal



Subject – 4 Heart Rate: 55bpm Diagnosis: Possibility of Sinus Bradycardia



Subject – 5 Heart Rate: 110bpm Diagnosis: Possibility of Atrial Tachycardia

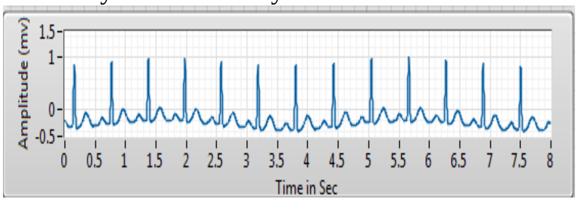


Fig.2. Measured ECG signals from various persons (subject 1 to 5)

ECG Characteristics	PR Interval (sec)	QRS Interval (sec)	R-R Interval (sec)	Diagnosis for abnormalities in ECG
Standard	0.12 to 0.2	0.08 to 0.10	0.6 to 1.0	
Subject-1	0.12	0.08	0.9 (Regular)	Normal
Subject-2	0.14	0.09	0.9 (Regular)	Normal
Subject-3	0.135	0.08	0.9 (Regular)	Normal
Subject-4	0.14	0.12	0.6 (Regular)	Possibility of Sinus Bradycardia
Subject-5	0.08	0.05	1.2 (Regular)	Possibility of Atrial Tachycardia

Table.2. Consolidated report of ECG characteristics of subject 1 to5

By summarizing the ECGs (Figure.2) and the corresponding reports (Table.2), it is identified that the ECGs of the subjects 1,2 and 3 have normal PR, QRS and RR intervals, which informs that the persons are having normal cardiac cycle without any arrhythms.

Whereas the reports of subject-4 describes a prolonged QRS interval of 0.12sec and there by the no of ECG cycles per specified time interval are less, which is predominant in fig2. This kind of arrhythmia is called ***sinus bradycardia***, in which the rate of P wave is reduced to 50bpm.

The reports of subject-5 describes a reduced PR and QRS intervals which results in increased rate of P wave (110bpm) for the subject5. This kind of arrhythm is called ***sinus tachycardia***. The rate of P wave is increased, more number of ECG cycles are observed in specific time duration.

The developed system is cost effective and can be easily applicable for acquisition and analysis of ECG signals for diagnosing various cardiac diseases. The experiments and results discussed in this work are limited to few arrhythms in heart. It can also be extendable to diagnose various other cardiac ailments. After standardization, the system could able to give reliable reports under prescribed specifications.

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