LabVIEW-Based Physiological Parameters Monitoring System for Patient Healthcare

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***Abstract*— Monitoring system referred to repeated or continuous measurement of various physiological parameter of patient. In the present paper by using the LabVIEW which is graphical programming language, clinically important parameters i.e. Temperature, SpO2 and Electrocardiogram, are obtained processed and displayed in a graphical user interface, then get available on web page in real time to be viewed by an authorized doctor. The algorithm is evaluated with ECG data files, with different ECG morphologies and noise content taken from Biopac MR150 instrument for ecg acquisition which contains 1000 samples per ECG, recorded at a sampling frequency of 150Hz. All this data get available to physician, by using various web publishing tool in LabVIEW, who is at remote location. In this work we have developed an algorithm based on wavelet transform approach using LabVIEW 10.(Laboratory Virtual Instrument Engineering Workbench).**

***Keywords*— LabVIEW, Web Publishing Tool, VI, ECG, Wavelet Transform, Report generation.**

I. Introduction

This paper presents our work on the design and development of a PC based remote patient monitoring system which allows the patient to be monitored remotely from any location. In medicine, monitoring is the observation of a disease, condition or one or several medical parameters over time. It can be performed by continuously measuring certain parameters by using a medical monitor (for example, by continuously measuring vital signs by a bedside monitor), and/or by repeatedly performing medical tests. Transmitting data from a monitor to a distant monitoring station is known as telemetry or biotelemetry. The survival rate of the emergency cases is highly influenced by the time taken for reaching care giving point. In order to increase the chances of survival, time constraint has to be eradicated. Emergency cases need immediate surgical intervention and intensive monitoring, hence OR and ICU have to be prepared accordingly. For this one needs to monitor the vital parameters of the patient and do a quick diagnosis for choosing treatment procedure. For minimizing the time utilized for procedure preparation, it would be convenient if patient's clinical data reaches doctors well in advance; this is where telemetry comes to play, so the doctors are well prepared on the arrival of patient.With virtual instrumentation, engineers use graphical programming software to create user-defined solutions that meet their specific needs, which is a great alternative to proprietary, fixed functionality traditional instruments.

Execution is determined by the structure of a graphical block diagram (the LV-source code) on which the programmer connects different function-nodes by drawing wire. National Instruments LabVIEW is an industry-leading software tool for designing test, measurement, and control systems. By using the integrated LabVIEW environment to interface with real-world signals, analyse data for meaningful information, and share results, we can contribute the whole patient monitoring system. LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution order. LabVIEW programs are called Virtual Instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. LabVIEW contains a comprehensive set of tools for acquiring analyzing, displaying, and storing data, as well as tools to help you troubleshoot our code.

II. OVERVIEW OF LabVIEW:

A. Signal Acquisition:

LabVIEW is designed to be used with hardware supported by the National Instruments DAQmx driver. This includes most USB, PCI, and PXI data acquisition devices with analog input.

A simulated NI-DAQmx device is a device created using the NI-DAQmx Simulated Device option in the menu of MAX for the purpose of operating a function or program without hardware. This graphical software is also designed to be used with a standard sound card and microphone for acqiring sound signal.

B. *Signal Processing and Analysis*

LabVIEW contains over 850 built-in analysis functions to simplify development for a broad range of applications. Some commonly used libraries include:
Probability and Statistics, Optimization, Linear Algebra
Curve Fitting, Signal Generation, PID Control Algorithms
Fuzzy Logic, Bode Plot.

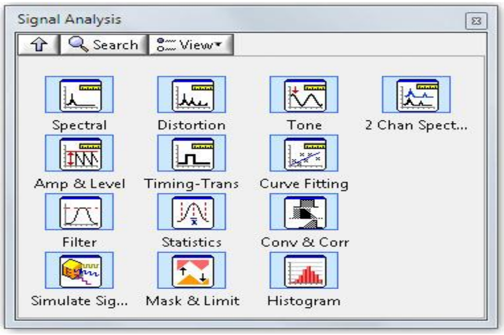

Fig 1: Signal Analysis tool in LabVIEW

C. *Distributed Application*

LabVIEW have the ability to develop distributed applications using TCP/IP, Internet Toolkit, VI Server, Front Panel Web Publishing, Remote Data Acquisition (RDA).

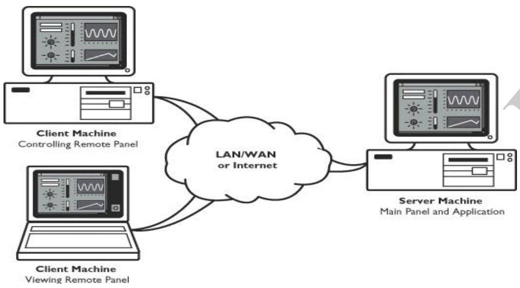

Fig 2: Data Transmission through LAN

III. SYSTEM REPRESENTATION

The design of this system consisted of three parts: sensors, signal processing circuits, and a user-friendly graphical user interface (GUI). The first part involved selection of appropriate sensors. For ECG, disposable Ag/AgCl electrodes; for temperature, Thermister and LM35 precision temperature sensor were selected.

The second part consisted of processing the signals obtained from these sensors. This was achieved by implementing suitable amplifiers and filters for the vital signs. The final part focused on development of a GUI to display the vital signs in the LabVIEW environment.

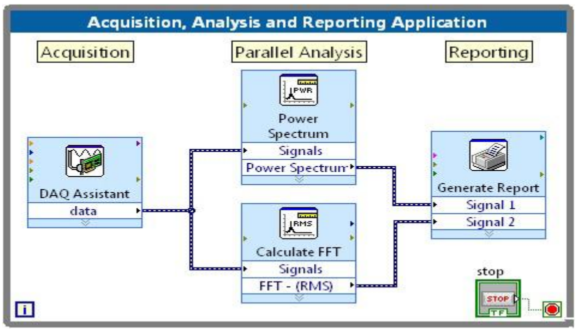

Fig 3: System Representation

The signal acquired here are Temperature and ECG. The acquired signals are made available to the DAQ card which is BNC 2120 board having analog and digital input/output channels interface in LabVIEW for further analysis that can be designed in the block diagram panel.

IV. MEASUREMENT OF VARIOUS PARAMETERS:

A. *Temperature Measurement*

For the measurement of temperature of patient's body here Thermister is used which working on principle that the resistance changes with the changes in temperature [1]. Bead type thermister as shown in fig 4(a) is normally used. This gives temperature in Fahrenheit , which was then converted into Celsius by the following formula as in

CELCIUS [°C] = [F]-32*5/9

The data acquisition board can only measure voltage, not resistance thats why construct a voltage divider circuit to measure resistance,

Fig 4(a):Thermister Fig 4(b): LM35 Temperature Sensor

generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. addition to thermister we can also use LM35 as shown in fig 3(b) which is precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature It has thhe scale factor of .01V/◦C, and normally rated for full -55◦C to +150 ◦C range. Block diagram for temp measurement is shown in following fig.

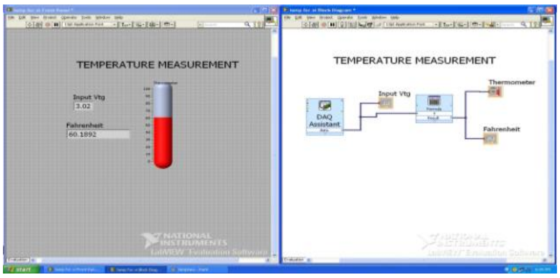

Fig 5: Front Panel and Block Diagram for temp measurement

B. *SpO2 Measurement*

Pulse Oximeter is a device used to measure the oxygen level in our blood. Our lungs have efficiency to diffuse oxygen into our blood hemoglobin to make it oxygenated hemoglobin (HbO_2) and after the exchange of oxygen with Carbon-di-oxide occurs between tissue and blood then the blood becomes deoxygenated hemoglobin (Hb) [12]. Following figure shows the basic principle of sensor, to measure the oxygen level in blood.

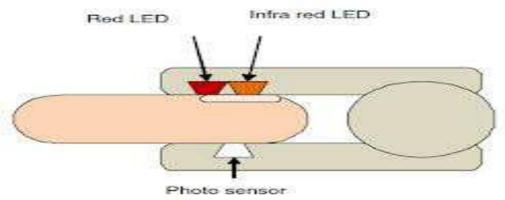

Fig 6: Principle of Sensor

To achieve the Oxygen Saturation Level in blood we have to use two LED's as transmitters and a Photodetector as the receiver[1][5]. By calculating the light absorption of the two wavelengths, the processor can compute the proportion of oxygenated hemoglobin. Figure shows the hardware of pulse oximeter circuit mounted on PCB by using basic electronics component. This device consists of slot in which patient finger has to placed, output of this circuit is linked to NI BNC2120 hardware for further processing.

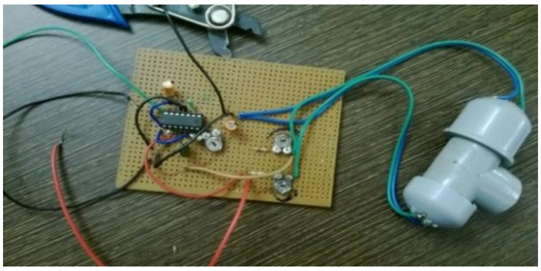

Fig 7: Hardware of Pulse Oximeter

This set up was then connected to the DAQ for acquiring the signal in LabVIEW for calculating the ratio of absorption of oxyhaemoglobin and deoxyheamoglobin which was derived in LabVIEW.

C. *ECG Measurement*

The electrocardiogram (ECG) is a technique of recording bioelectric currents generated by the heart. Clinicians can evaluate the conditions of a patient's heart from the ECG and perform further diagnosis. ECG records are obtained by sampling the bioelectric currents sensed by several electrodes, known as leads.

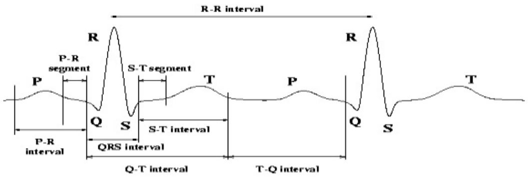

Fig 8: Normal ECG Waveform

Figure 8 shows the basic ECG waveform. The heart produces a small electrical signal that can be recorded though skin surface electrode as 'Electrocardiogram'. The peak values of ECG signal are of the order of 1m volt, which is very low, so to amplify the raw ECG signal amplitude, we need Amplifier [11]. The metallic electrode applied to skin using ECG gel, produces a half cell potential(HCP). This HCP is DC and of order of 1-1.5V, which is much higher than ECG signal. This electrode offset potential can be removed using AC coupled differential amplifier.

Typical ECG signal has frequency component in the range 0.05Hz-100Hz. To reduce patient movement artifact, frequency range can be further reduced to 0.05-40Hz. Notch filter is included to reduced 50Hz line interference. So an AC coupled instrumentation Amplifier have to be designed. Following figure 9 shows the circuit diagram for particular ECG Amplifier.

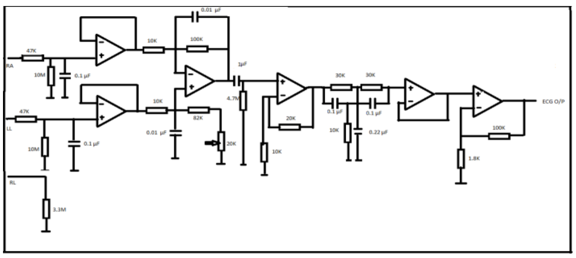

Fig 9: ECG Amplifier

Generally, the recorded ECG signal is often contaminated by noise and various artifacts. In order to extract useful information from the noisy ECG signals, we need to process the raw ECG signals, Preprocessing ECG signals helps us to remove contaminants from the ECG signals. the power line interference and the baseline wandering are the most significant and can strongly affect ECG signal analysis. The power line interference is narrow-band noise centered at 60 Hz (or 50 Hz) with a bandwidth of less than 1 Hz. Usually the

ECG signal acquisition hardware can remove the power line interference[4].

The wavelet transform plays a very useful role in removing noise from useful signal [10]. In the LabVIEW Advanced signal processing toolkit there is WA Detrend VI available[2], which can remove the low frequency trend of a signal. This VI removes the trend from 1D signals by setting the approximation coefficients to zeros. In this, **threshold frequency** specifies the upper frequency limit of the trend that this VI removes from the **signal.** The **threshold frequency** determines the wavelet transform level. The wavelet transform level specifies the number of levels in the discrete wavelet analysis.

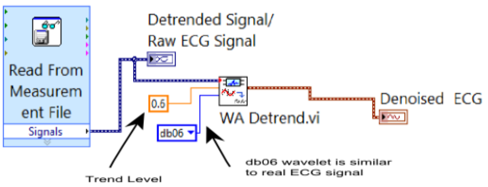

Fig 10: WA Detrend.VI

Example shown in figure 10, uses the Daubechies6 (db06) wavelet because this wavelet is similar to the real ECG signal [2]. In this example, the ECG signal has a sampling duration of 60 seconds, and 1000 sampling points in total, therefore the trend level is 0.69. In this input is taken from database collected from BIOPAC MR 150 instrument. However because after the removal of baseline wandering from ECG Signal other wideband noises, higher in frequency still affecting the ECG signal and are not easily get removed by hardware equipments.

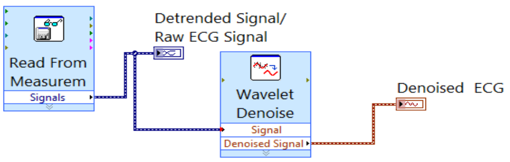

Fig 11: Noise removal using WA Denoise VI

This wideband noises causes due to pop-up of electrode, movement of patient, also due to electromyograph might still affect the main characteristics of the ECG signal. To remove the wideband noises, we can use the Wavelet Denoise Express VI [4]. Figure 12 shows the results, where unwanted noise get removed from raw ECG signal and finally we get denoised ECG Signal.

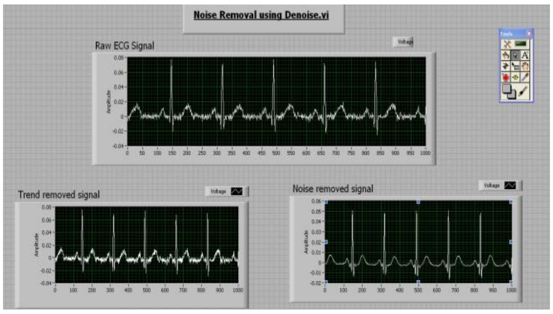

Fig 12: (a)Original ECG, (b) Base line wander removed signal and (c) Denoised signal

For the purpose of diagnosis, we 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 [7][8]. It supplies evidence for the diagnoses of cardiac diseases. these tools can be also used in other biomedical signal processing applications such as Magnetic Resonance Imaging (MRI) and Electroencephalography (EEG). This application note has demonstrated how to use these 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.

V. REPORT GENERATION

With the LabVIEW Report Generation Toolkit, we no longer have to learn the complex object models of Microsoft Word and Excel to generate a report. Report Generation Toolkit for Microsoft Once is a library of flexible, easy-to-use VIs for programmatically creating and editing Microsoft Word and Excel reports from LabVIEW.

Using report generation toolkit present in LabVIEW a real time patient record containing basic patient information such as name, age, gender and clinical information like heart rate, all parameters of ECG waveform is generated.

VI. WEB PUBLISHING TOOL

It create Embed, static or animated images of the front panel, directly creating an HTML document. To display front panels on the Web, the VIs must be in memory on the computer. Web Server is used to publish images of front panels on the Web. By default, after enabling the Web Server all VIs are visible to all Web browsers. The GUI settings and LabVIEW code were password protected, thus no one without proper authorization could observe or alter the settings and the code. LabVIEW uses its own web server to publish the front panel to a web browser so the VI can be accessed remotely [1]. It Causes the embedded front panel to automatically request control over the remote VI after the connection is established.

Fig 13: Web publishing Tool in LabVIEW

VII. CONCLUSION

The use of LabVIEW and data acquisition in biomedical makes the real time monitor systems with very high performance, low cost of development, more reliable and flexible. LabVIEW and the signal processing-related toolkits can provide us a robust and efficient environment and tools for resolving ECG signal processing problem. The graphical approach also allows non-programmers to build programs simply by dragging and dropping virtual representations of lab equipment with which they are already familiar. One benefit of LabVIEW over other development environments is the extensive support for accessing instrumentation hardware. The most advanced LabVIEW development systems offers the possibility of building stand-alone applications. Furthermore, it is possible to create distributed applications, which communicate by a client/server scheme. In future, we going to provide SMS facility to the physician about patient health conditions using PDA module of LabVIEW platform.

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