Real Time Patient Tele-monitoring System Using LabVIEW

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Abstract—Patient tele-monitoring is remotely monitoring the vital parameters of patient and providing them to the doctor at remote location than the patient thus ensuring mobility of both patient and the doctor. In the present paper the physiological parameters such as Electrocardiogram, Heart rate, SPO2, Phonocardiogram and Temperature are obtained processed and displayed in a graphical user interface, then provided dynamically to a web page in real time to be viewed by an authorized doctor, if anyone of the vital parameter go out of normal range than an alert file is generated by the system.Finally alerts will be given in twoways, firstly on the doctor's mobile about the vital signs of the patient using Android application and secondlyalert given by an email notification. All the three objectives have been implemented using LabVIEW.

Index Terms—LabVIEW, Patient tele-monitoring,Electrocardiogram, Heart rate,SPO_2,Phonocardiogram, Temperature, Patient monitoring system(PMS),Web page,Mobile,Email.

1 INTRODUCTION

The modern visionary of healthcare industry is to provide better healthcare to people anytime and anywhere in the world in a more economic and patient friendly manner. Therefore for increasing the patient care efficacy, there arises a need to improve the patient monitoring devices and make them more mobile. The medical world today faces two basic problems when it comes to patient monitoring, firstly the need of healthcare providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved. As the bioinstrumentation, computers and telecommunications technologies are advancing, it has become feasible to design a home based vital sign telemonitoing system to acquire record, display and transmit the physiological signal from the human body to any location. [1] Remote patient telemonitoring system using Java enabled 3G mobile phone enables doctors to monitor the vital biosignal such as *ECG, Respiration, SPO_2,*and so on of patients in ICU/CCU using the real time waveform and data monitoring function of installed Java based application on the mobile phone. [2] The need for real time notification of vital signs of patient to the doctor is of prime importance, thus the need of active database system arises, that is grouped with patient monitoring device. The JMS was used to form the notifications. [3] The importance of PMS in medical treatment is very high; therefore the medical manufacturers are introducing centralized PMS. In centralized PMS all patient monitors are connected with a single server based PMS. The TCP/IP protocol suite based architecture systems are capable to upgrade the PMS's firmware and software through dedicated TCP/IPprotocol suite via open communication network. For a more efficient patient care by the caregivers, the PMS must be incorporated with smart alarm systems. [4] Thus the new PMS with intelligent alarm system has significantly improved sensitivity and specificity of monitoring and also demonstrated the feasibility of real time learning at the bedside. In order to alert the patient caregivers about the vital signs of patient these alarm systems are characterized based on the signal characteristics such as for ECG, attributes like R-R interval, peak detection and for other parameters their normal range sets the alarm system. [5] The computer based signal acquisition; processing and analysis system using LabVIEW is used as peak detection tool in ECG and as a filtering tool for biomedical signals. [6]The computer-based patient education can help improve the patient's awareness and understanding of his or her disease, thus the efficacy of treatment can be increased. This paper discusses the aspects of acquisition of physiological parameters likeECG, PCG, Temperature, SPO_2 andHeart rate, pre-processing them and displaying them in a graphical user interface for being viewed by the doctor and also sending the clinically useful data on a personalized website and alert message is generated by the system finally alerts will be given in two ways, firstly on the doctor's mobile about the vital signs of the patient using Android application and secondly by an email notification.

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2 SYSTEM REPERESENTATION

The Real time vital parameter transmitting system schematic is shown in Fig. 1 with both electronic hardware and software components. The electronic component covers two aspects. The first ensures the acquisition and transmission of the signal using Acquisition card DAQmx, the second receives the signals on the server side using LabVIEW application and also is responsible for sending alert sms about that measurement information on physician's mobile.

3 Materials and Mehtods

This section discusses the basics of LabVIEW, signal acquisition, processing and transmission.

3.1 LabVIEW

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 using intuitive graphical icons and wires that resemble a flowchart. The software also includes number of advanced mathematics blocks for functions such as integration, filter and other specialized capabilities. The LabVIEW Professional Development System allows creating stand-alone executables and the resultant executable can be distributed an unlimited number of times. The run-time engine and its libraries can be provided freely along with the executable.

3.2 Signal Acquisition

The signal acquired here are ECG, SPO_2 PCG, TEMEPERATURE .These signals acquired through sensors connected to PC having a LabVIEW platform through a DAQ device interfaced through an ELVIS Prototyping board having analog and digital input/output channels. The acquired signals are made available by the DAQ user interface in LabVIEW for further analysis that can be designed in the block diagram panel.

3.3 ECG Recording

The low noise ECG signal is acquired by National Instrument Educational Laboratory Virtual Instrumentation Suite (NI ELVIS) using 3-lead system. The acquired signal is further processed by LabVIEW which is having signal processing module. Signal processing tool kit contains digital filter and several transform such as Wavelet, Fast Fourier Transform (FFT) etc. The appropriate filter and transform have been implemented and this gives noise free signal and from that fast and reliable estimation of clinically important parameter such as R-R interval and ECG peaks accurately achieved using LabVIEW. In order to achieve the above functionalities, firstly baseline filter to removing the baseline noise and then signal applied to the wavelet denoise which performs noise reduction for 1D signal by using the discrete wavelet transform (DWT) and then passed the signal for Multiscale Peak Detection which used to detect peaks in a signal and from that each peak we determine the amplitude of each peak and width of signal.

3.4 Heart Rate Determination

Heart rate is determined by the number of heartbeats per unit of time, typically expressed as beats per minute (BPM). The measurement of heart rate is based on the Pan Tompkins algorithm for QRS detection. The algorithm is based on analysis of the slope, amplitude and width of QRS complexes. The algorithm includes a series of filters and methods that perform low pass, band pass, derivative, squaring, integration, adaptive thresholding and search procedure. Calculation of Heart rate based ECG graph collector present in LabVIEW that collects input signals and returns the most recent data, up to the specified maximum number of sample per channel. The maximum value of the peaks and pass them to waveform peak detection tool which defines the peak value for the particular given width and after that the peak value was divided by width and multiplied by 60 for the measuring heart rate in beats per minute, and then compared with normal heart rate range which gives the Bradycardia and Tachycardia conditions of the patient, when any of these conditions occurs sound and light alarms automatically start.

3.5 PCG Recording

The PCG (Phonocardiogram) is a vibration or sound signal related to the contractile activity of cardiohemic system and represent recording of heart sound signal. Recording of PCG requires a transducer to convert the vibration or sound signal into an electrical signal and then this signal was given to PCG amplifier. This setup was connected to the NI DAQ for acquiring the signal. After acquiring the signal, FFT was taken for getting the spectrum and then filtered by low pass filter to remove the noise form signal and thus giving accurate result of heart sound waveform.

3.6 SPO_2 Calculation

Pulse oximeter is a simple non-invasive method for monitoring the percentage of heamoglobin (Hb) saturated with oxygen (SPO_2).The pulse oximeter consists of probe attached to the patient's finger or ear lobe which is linked to NI ELVIS hardware for further processing. Pulse oximeter uses the basic principle of a pair of small LEDs operating at a different wavelengths; one red LED with a wavelength of 660nm, the other, an infrared LED with a wavelength of 910nm. The LEDs are designed to place opposite a photodiode that detects the transmitted light from LEDs. Absorption on each wavelength differs significantly for the oxyhaemoglobin and deoxyheamoglobin. Therefore from the difference of the absorption of the red and infrared light into ratio between oxy/deoxyhaemoglobin can be calculated and then this signal was given to pre-amplifier and low pass filter circuit for further processing. The electronic circuit for pulse oximeter is as shown in Fig 2. 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 by equation as in (1).

$$R = \frac{AC_R/DC_R}{AC_{IR}/DC_{IR}} \qquad (1)$$

R= ratio of absorption of oxyhaemoglobin and deoxyheamoglobin.

The value of $SPO_2$was then calculated by the equation as in (2)

$$SPO_2 = (110-25R)\ \% \qquad (2)$$

The value of $SPO_2$was then compared with the normal value which gives alert alarm, when the value of SPO_2decreases from the normal range. And that will be helpful to physician for further patient analysis.

3.7 Temperature Monitoring

The temperature sensing is performed by using a thermistor with excitation voltage of maximum +12v and GND based on the principle that the resistance changes with the temperature change. This is given by Steinhart-Hart equation as in (3).

$$1/T = a + b\ \ln(R) + c\ \ln^3(R) \qquad (3)$$

Where, $a= 1.4*10^{-3}$
$b=2.37*10^{-4}$
$c=9.90*10^{-8}$

This gives temperature in Kelvin, which was then converted into Celsius by the following formula as in (4).

$$\text{CELCIUS } [°C] = [K]-273.15 \qquad (4)$$

Celsius was then converted into Fahrenheit by the following formula as in (5).

$$\text{FARENHEIT } [F] =[°C]*9/5+32 \qquad (5)$$

4 REAL TIME TELE-MONITORING USING LABVIEW

The LabVIEW has been used to build computer graphics interface (CGI) programs and URLs, to send and receive data using the Telnet protocol, to store and retrieve files from FTP servers and to publish VIs on the Web browser.

4.1 Web Publishing Tools

LabVIEW have internet toolkit including the G Web Server, which is an HTTP/1.0-comapatible server used to run applications on the Web. Servers and CGI applications intercommunicate through environmental variables and standard inputs and output. When HTTP executes CGI VI, standard input data was generated as string and a request to send generate string as well is generated.

4.2 Publishing Front Panel with G Web Server

Here the G Web server was used to publish image of front panelon the Web. Using this static or animated front panel images can be loaded. The G Web server can generate images in JPEG or PNG image formats. All above described features have been used in this application to transmit data on Web. The acquisition is triggered by the physician remotely, once he decided to view the vital parameter of one of his patients, the request was redirected from the asp.net based website to G Web server which executed remotely a LabVIEW application embedded in the patient's pc and the session was opened, then the signal was displayed dynamically in the web page at the physician side. For this the patient is already prepared with the electrodes on, which means arrangement between patient and physician should have been prepared which is shown in Fig 3. Fig 4 shows all patient vital parameter signal accessed from the physician side. From this physician can retrieve all information about his patients that he may need while assessing their health condition, such as Heart rate, temperature, SPO_2 etc.

4.3 Alternative Recording Possibility

In some cases while assessing the health condition of a patient, need to go back to previous data occurs. Each session is saved in TDMS file now and then and then uploaded at the end of session to the server, saving this file the name and photo of the patient along with the session date, allows the physician to retrieve the desired session by date among all recorded session and patient information. Each and every process can be controlled by the physician; he can put a limitation on what recording time of signal to be saved.

4.4 Real Time Report Generation Using 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 temperature, spo_2,heart rate, ECG waveform and PCG waveform is generated.

4.5 Alerts on Mobile Using Android Application

Android is a software stack for mobile devices that includes an operating system, middleware and key applications. The SDK provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming. An application inMOTODEV Studiobased on Eclipse was developed. An android 2.3.3 version phone for receiving alert message which is mainly developed using MOTODEV Studio was used. The code for this application is formed in java. Layout of the alert application is shown in Fig 5. This application runs through internet. When alert file is generated by the LabVIEW, it will be automatically uploaded using FTP on Web using AutoIt software. Alert application works continuously in background of mobile whenever it finds file, mobile vibrates and downloads file from the web and opens it in Microsoft office automatically. Requirement for operating application in physician mobile are android phone and internet connection in mobile.

4.6 Email Notification

This can be done using AutoIt software which works like scripting language designed for automating the Windows GUI and scripting. When alert file is generated by the LabVIEW, it will automatically send mail using Email notification application.Alert Email notification on mobile has been shown Fig.6.

5 RESULT AND DISCUSSION

This system can be used to transmit the patient vital parameter information in real time to remote location and can be viewed by the care giver as shown in Fig 4. Also a printable patient report can be generated any time as per the need. One such generated report was shown in Fig 7.

As this is medical application, reliability is needed in the first place. A reliable TCP protocol was used in this application which was implemented in LabVIEW. The system was tested for data acquisition for ten subjects and the following data was obtained. This has been represented in the interpretation table as shown in table 1.

6 Conclusion

In this paper, telemonitoring application is presented which allows doctor to view his patient's vital parameter remotely and dynamically in a Web page in real time and does not need to have any special requirement on his PC; all he needs is an internet access.

For the patient side, it is a home based LabVIEW application embedded in a home PC, during signal acquisition.

7 Future work

In future work the transport protocol (TCP/IP) can be replaced by the Real Time Transport protocol RTP, thus making it more secure, by implementing the RTP in the developed LabVIEW application.

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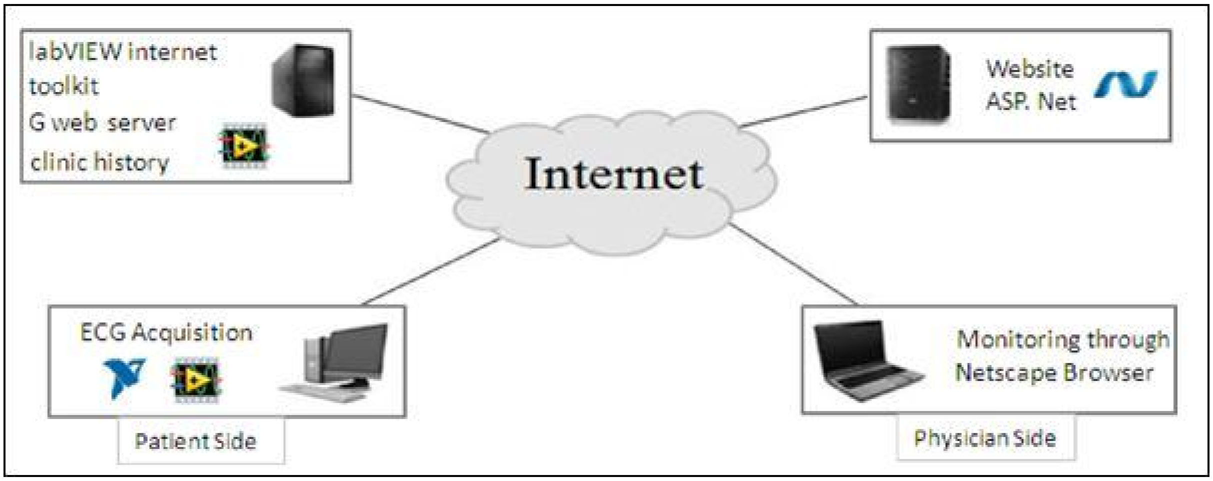

Fig. 1Real Time Remote Monitoring Schematic

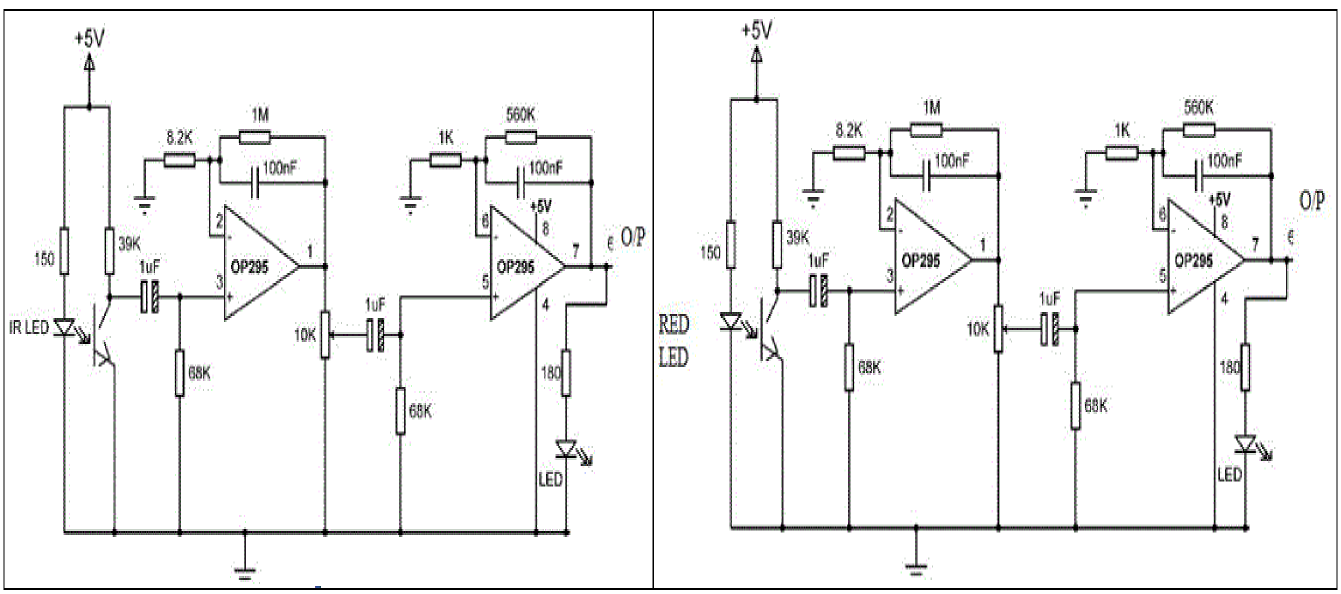

Fig. 2 Basic electronic circuit for pulse oximeter

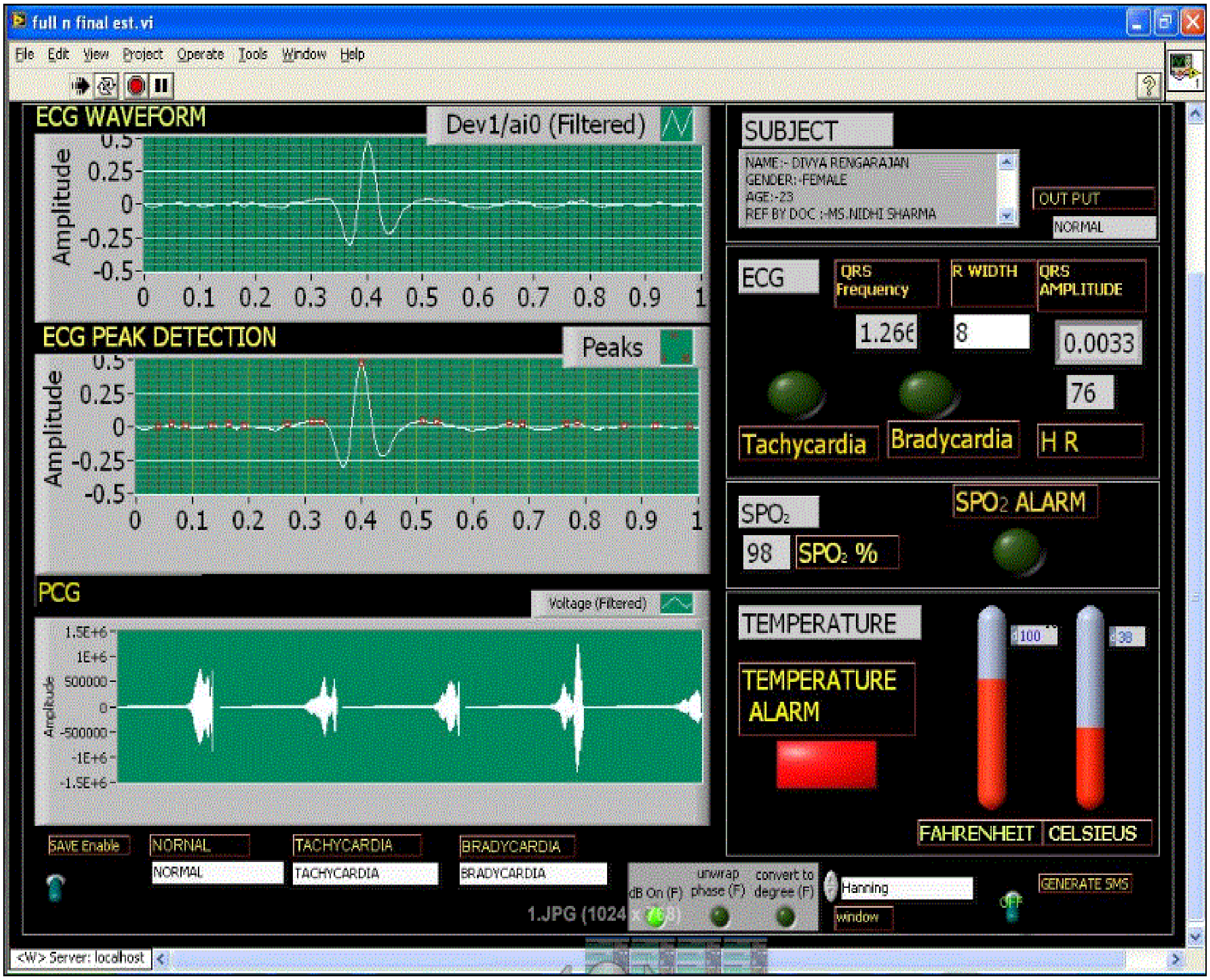

Fig. 3 Patient side monitoring

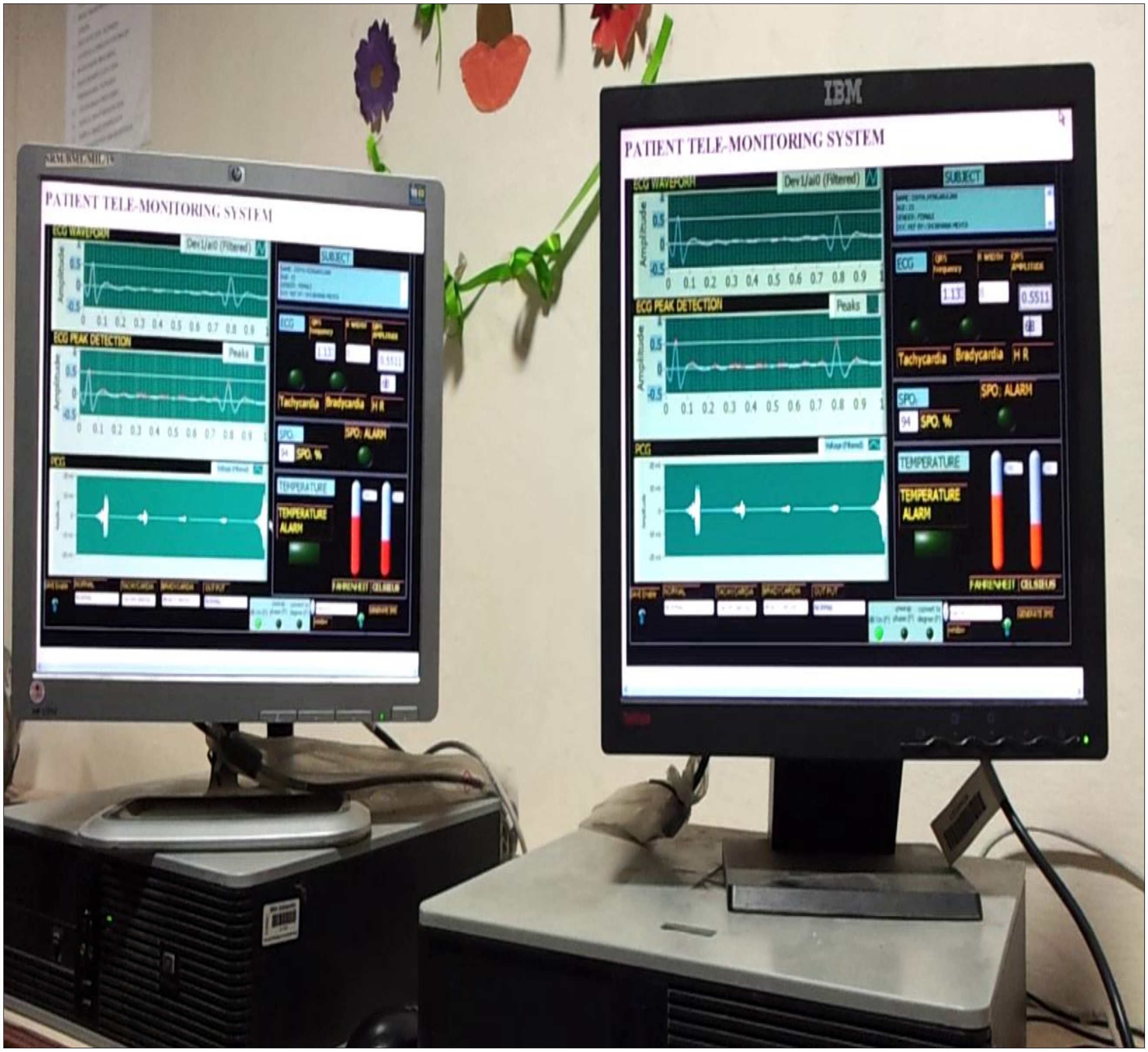

Fig. 4 Physician side, vital parameter of selected patient

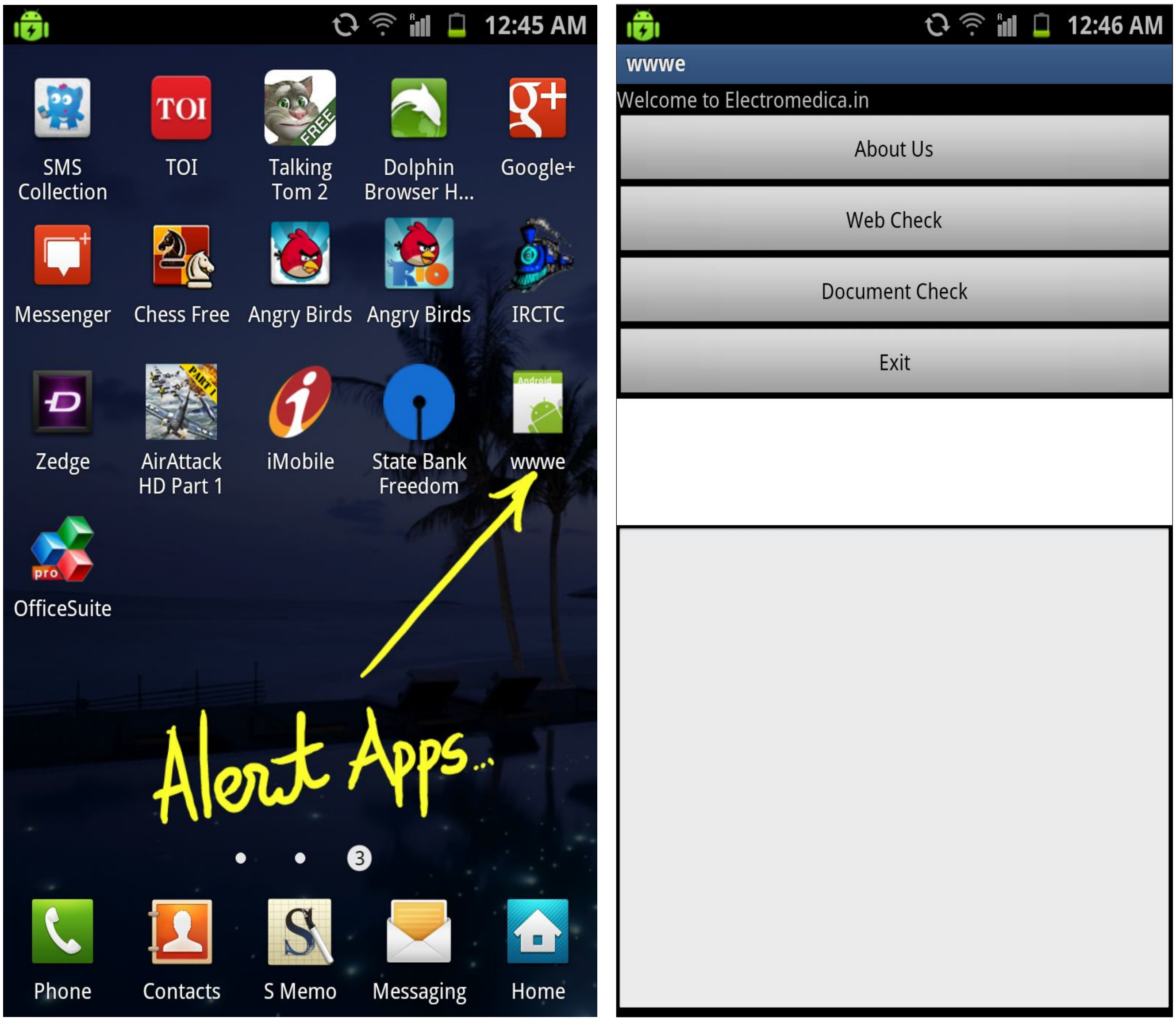

Fig.5 Alert application on Android mobile

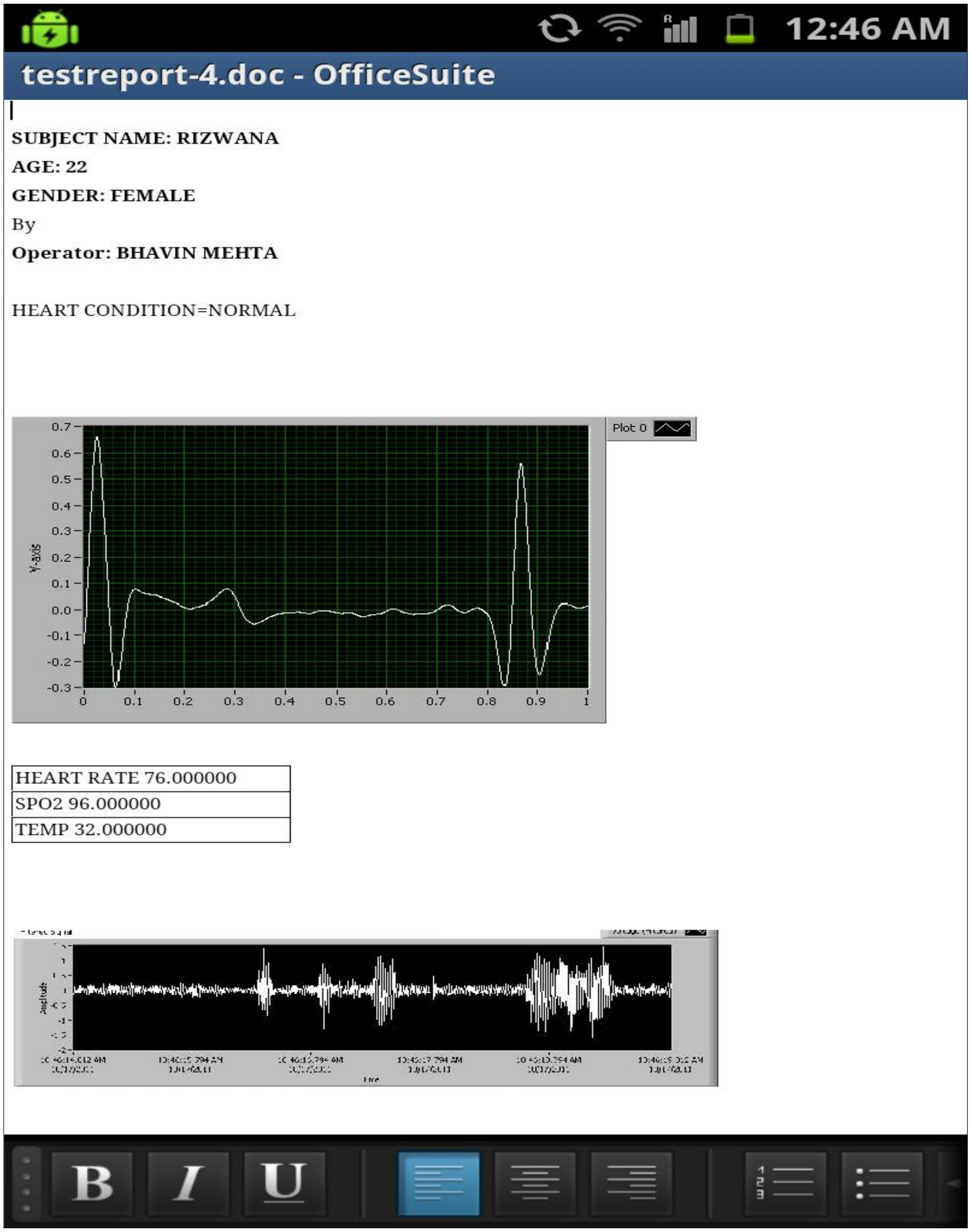

Fig.6 Alert Email notification on mobile

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SUBJECT NAME: DIVYA

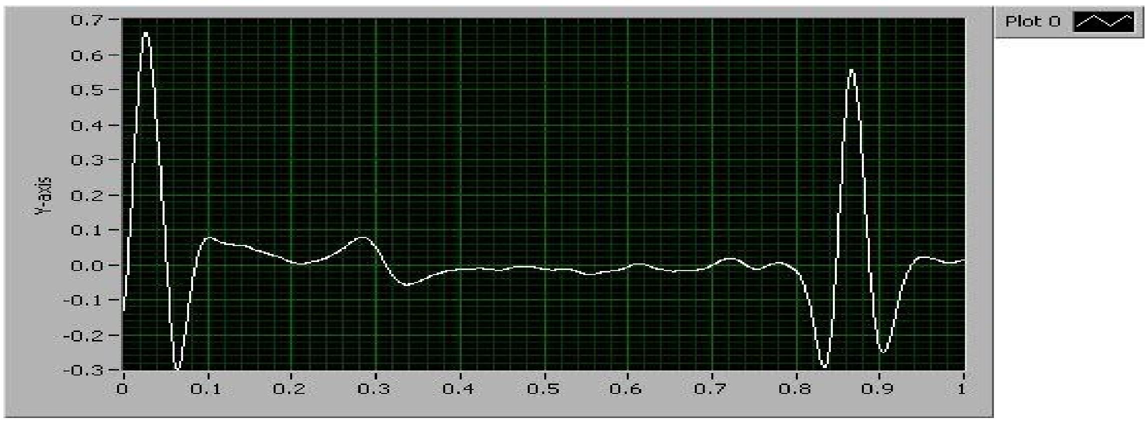
AGE: 22

GENDER: FEMALE

By

Operator: BHAVIN MEHTA

HEART CONDITION=NORMAL



HEART RATE 76.000000	
SPO2 96.000000	
TEMP 32.000000	

PCG GRAPH

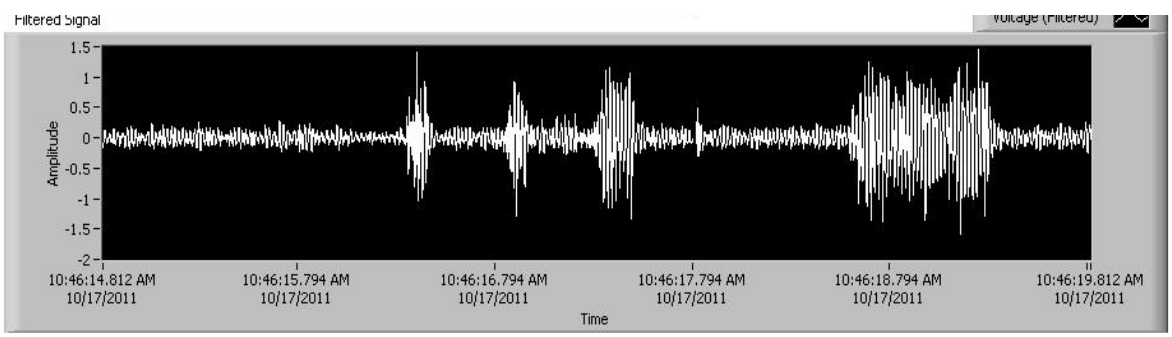


Fig.7 Real time printable patient report

TABLE 1

INTERPRTATION TABLE

CASE	TEMPERATURE (^{0}C)	SPO_2 (%)	HEART RATE (Beats/Min)	R-WAVE AMPLITUDE (mV)	QRS COMPLEX WIDTH (Sec)	INTERPRETATION
CASE 1	36	98	74	4.6	0.09	NORMAL
CASE 2	35	96	70	**3.8**	0.11	**ABNORMAL**
CASE 3	37	99	81	5.07	0.08	NORMAL
CASE 4	36	99	72	4.98	0.12	NORMAL
CASE 5	36	96	70	4.45	0.07	NORMAL
CASE 6	37	97	**56**	**3.2**	0.09	**ABNORMAL**
CASE 7	36	96	71	**3.54**	0.11	**ABNORMAL**
CASE 8	35	98	69	4.76	0.06	NORMAL
CASE 9	35	96	**95**	4.73	0.03	**ABNORMAL**
Case 10	37	99	90	4.52	0.12	NORMAL

NORMAL RANGE OF THE VARIOUS MEASURED PHYSIOLOGICAL PARAMETERS:

TEMPERATURE: (35-37) °C

SPO_2: 96% - 99%

HEART RATE (Beats/Min - bpm): 60-90bpm

R-WAVE AMPLITUDE (mV): >4.5 mV

QRS COMPLEX WIDTH (Sec): (0.04-0.12) mSec