Design of Android-Based Remote Patient Monitoring System

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***Abstract*—Efficient real-time monitoring systems for Patients with critical health condition have been always helpful for making timely decisions to save the lives. In such systems, the useful monitored factors include SPO2 (Oxygen Saturation in Blood), heart rate as well as temperature. Further, there are hundreds of patients in ICUs under monitoring systems in different hospitals and in different regions under fewer doctors/consultants on the move. Under above facts, a prototype for continuous monitoring of patient's health statistics such as SPO2 and temperature along with a bed-side desk using a PC/Laptop (bio instrumentation) working as Server Database with an application layer top transfer data on Android Application Server is successfully developed. This Android application accessing real-time monitored factors using Server Database allows the consultant to monitor patient's vitals data using his smart phone on move being at any hospital or city that creates easiness to handle any emergency and reduces Patient risks.**

Keywords*—Monitoring system; SPO2; temperature; android application; bio instrumentation

I. INTRODUCTION

The Present research work on healthcare system aims to deliver better healthcare to patients anytime and anywhere in low cost and friendly manners. Therefore, for increasing the patient care efficiency, there is a need for continuous monitoring and consultation to avoid any life loss. Health care industry today faces some basic problems when it comes to patient monitoring. Like firstly, less number of Surgeons/Doctors, which is a reason that patient is unable to get timely attention and good treatment. Secondly, increased population, which also increases the number of patients and aged persons require health care. In order to achieve better quality patient care, there is a need for an effective monitoring system which can help the patient to seek utmost attention from doctors and similarly can help doctors to treat as many patients being at distance or without any distance.

Thanks to recent advances in Telemedicine and Bioinstrumentation, it is possible to receive, process, record and transmit patient's physiological vitals (Signals presenting actual vitals level) to computer servers and to any location via internet servers. This advancement has not only a blessing for patients at outreach to get a good healthcare efficiently but also advantageous for doctors who can treat many patients at the same time. Further, with the prevalent android OS based smartphones, it is motivating to make an android application for doctors and consultants to access real-time patient monitoring data on the mobile phone application.

Today, into eager every day life, such is challenging in conformity with preserve a wholesome lifestyle, that's why improper health cover/checkup leads to increase the number of persons getting sick for for long time. The regular health check can be achieved with monitoring systems [1]. Generally, a monitoring system for a patient is a procedure where a Doctor can constantly screen patient's vitals in a from distance location. Since Traditional healthcare technologies have been confined to hospitals providing no mobile healthcare (monitoring or consultancy) resulted with wastage of time, money and ease, several research teams have been working on this bioinstrumentation via remote monitoring using different methods [2].

In literature, it can be found that different possibilities for realization of such bio-instrumentation and remote monitoring like in [3], with ATMEGA8L microcontroller with sensor network – a healthcare monitoring is achieved. The system generates a buzzer if patient vitals exceed the nominal value with no remote transmission [4]. Monitors patient's Sp02 with MCU, ZigBee chip, and Sp02 sensor where sensor transmits data to the router, which is further linked to personal computer lacking every time monitoring. After Microcontroller and WSN Based system, Step further towards mobile healthcare system promotes the use most common android plate form for patient's mobile monitoring and alerts. These phones can easily monitor record and receive data collected by bioinstrumentation section. This method provides more flexibility, accuracy, ease, and analysis and reduces extra expenditures. Like in [5] a system with a combination of GSM and GPS first traces outpatient in pain or needs assistance and then send an alarm message to consultants for health care. Further, use of small single chip using Tran's impedance amplification, photodiode current source and photodetector in [6] implements a pulse oximeter that helps in bio-instrumentation with ultra-low power usage. This research work includes developing patient monitoring system using android application plate form with essentials vitals such as include SPO_2 (Oxygen Saturation in Blood), Heart Rate as well as Temperature. This module will assist doctors to monitor a patient using a simple android application on a mobile phone being at distance.

The rest of this paper is organized as follows: Section II presents an overview about system design, Section III defines results, outcomes and analysis about the project and Section IV presents conclusion and Section V presents future work.

II. System Design

This system aims to develop 1) Pulse Oximeter and with Temperature sensor: This part consists of a temperature sensor, red LED, infrared LED, a phototransistor. The Arduino UNO microcontroller interfaces the circuit with a computer and 2) Design for patient bedside monitoring Desk for Consultants (a Connection between sensor parts, web server, and Android application): This part consists of GUI program to connect to connect sensor circuit and computer. Arduino programming calculates the value of temperature and % oxygen in the blood (SpO2) with easy to access interface for the end user (Consultants) to access the measured patient health patient data around the globe. The complete system is depicted in block diagram in Fig. 1.

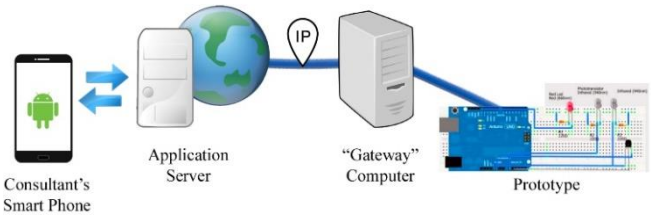

Fig. 1. Generalized block diagram.

The proposed architecture has following modules:

A. Temperature Sensor for Patient

LM35 sensor Fig. 2 whose output voltage is linearly proportional to Celsius is used with patient body contact; this is a precision integrated-circuit for temperature measurement with high preciseness, low self-heating and trimming less.

B. Pulse Oximetry Meter (POM) for Patient

The quantity of Oxygen saturation (Sp02) defines how much oxygen is present in the blood. Most common, reliable and non-invasive method based on Hemoglobin and Deoxyhemoglobin is Pulse Oximetry. Two different Light Wavelengths 660nm (red light spectrum) and 940 nm (infrared light spectrum) are normally used to determine the actual dissimilarity in the absorption spectrum of HbO2 and Hb [7]. At receiver, photodetector collects non-absorbed light from the two LEDs used and presents final output signal after OpAmp. The final output signal has both frequency and non-frequency parts which represent Intensity of Red LED (pulsatile arterial blood) and Intensity of IR LED (venous blood, tissue, and non-pulsatile arterial blood), respectively. The POM (Fig. 3) compares the two wavelengths and calculates Sp02 as follows: % Spo_2 = Intensity of Red LED/ Intensity of IR LED Equation (1).

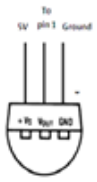

Fig. 2. LM35 with Arduino.

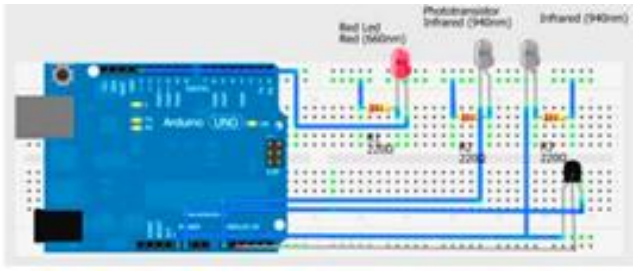

Fig. 3. POM circuit.

C. Arduino Interface with GUI and Android Application

The Arduino IDE is a cross-platform application written in Java and derived from the IDE with efficient compiling and uploading programs to the board (Android programming). Most common Arduino functions to make a program are Setup () and Loop (). The end part of this project is GUI for the end users. GUI connects the equipment to computer and simply click measures percentage of oxygen in blood and body temperature. Serial monitor panel will show the results of these parameters. Built-in GUI processing screen for real-time monitoring is present in the android application (Retomeier, Android Application), however, monitoring reading can also be performed LabVIEW or any other tool, and results can be exported to other software using the port.

Further, Android application (Fig. 4) has been developed for transmission of a vital signal from one device to another in real time. GUI is connected to the web using a port and same port address is given to the Android application. The android application lands on the given port address where the Acquired signals can be visualized.

Fig. 4. Android applications.

III. Result and Discussion

Results for temperature and readings are of Red and IR LED can be visualized in numerical format on Arduino's serial monitor (Fig. 5) and Graphical representation on android application for temperature and %SpO2 based on Equation (1).

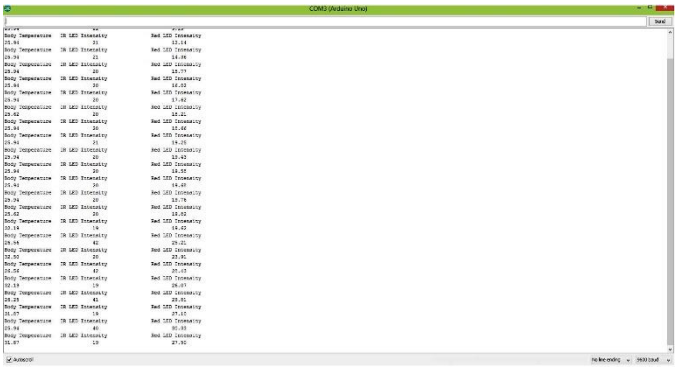

Fig. 5. Numerical results for LEDs and temperature.

TABLE I. READINGS ON ARDUINO SOFTWARE

Body Temp	Red Intensity	IR Intensity	%SpO2
28.12ºC	33.84	34.44	98.25783972mg
27.8 ºC	33.12	34.89	94.92691316 mg
27.98 ºC	32.52	34.12	95.31066823 mg
26.3 ºC	32.78	34.76	94.30379747 mg
24.31 ºC	31.23	34.18	91.36922177 mg
25.84 ºC	31.22	33.9	92.09439528 mg
26.65 ºC	31.78	33.67	94.38669439 mg
29.47 ºC	32.19	34.41	93.5483871 mg
27.49 ºC	31.78	33.98	93.5256033 mg
27.4 ºC	32.42	33.87	95.7189253 mg
27.12 ºC	31.32	33.21	94.30894309 mg
28.35 ºC	31.88	34.11	93.46232776 mg
26.11 ºC	31.67	34.05	93.010279 mg
27.3 ºC	32.09	33.19	96.68574872 mg
27.9 ºC	31.83	34.39	92.55597557 mg
27.46 ºC	31.42	33.5	93.79104478 mg
26.52 ºC	31.97	34.12	93.69871043 mg
28.74 ºC	31.71	34.22	92.66510812 mg
27.34 ºC	31.55	33.86	93.1777909 mg
28.62 ºC	31.8	34.67	91.72194981 mg
28.9 ºC	31.39	34.45	91.11756168 mg
29.71 ºC	31.08	33.76	92.06161137 mg
29.11 ºC	31.42	33.87	92.76645999 mg
24.17 ºC	31.12	34.08	91.31455399 mg
24.49 ºC	15.13	45.11	33.54023498 mg
24.66 ºC	12.45	49.14	25.33577534 mg
24.76 ºC	10.33	55.22	18.70699022 mg
22.7 ºC	9.23	57.76	15.9799169 mg
22.34 ºC	12.88	58.9	21.86757216 mg

Table I shows the reading acquired using the prototype, were compiled within thirty seconds, one reading each second, the first column contains the body temperature, second and third columns show the Red and IR LEDs' intensity respectively and the fourth column is showing the SpO2 values calculated using Equation (1) and shown in Fig. 7 and results on android application is shown in Fig. 8.

Fig. 6 represents graphical representation of readings of intensity of Red and IR LED.

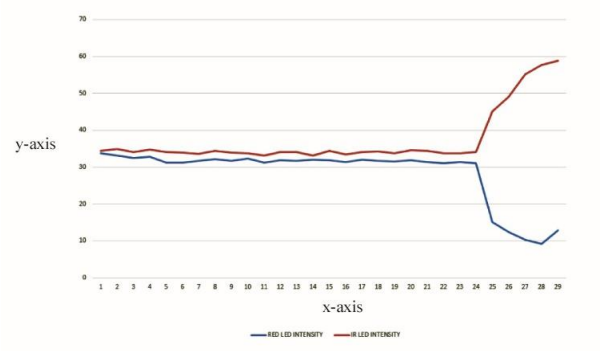

Fig. 6. Readings of intensity of red and IR LEDs.

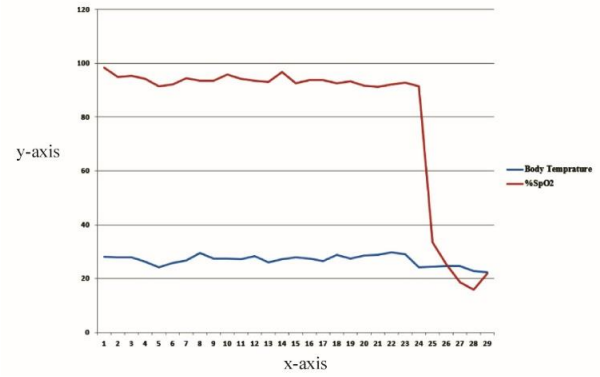

Fig. 7. Results for % SpO_2.

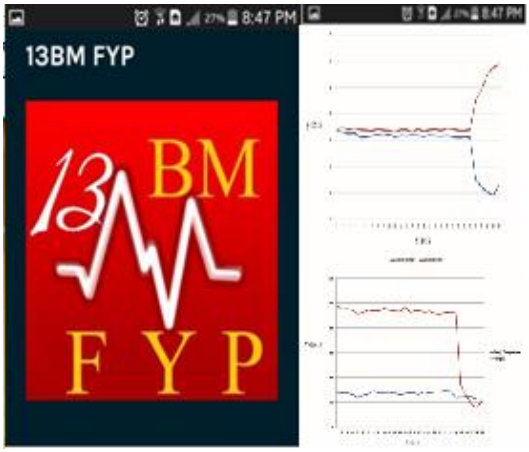

Fig. 8. Results on android application.

IV. CONCULSION

A Well Designed system for Android-based Bed-Side Monitoring Desk is presented and tested to access patient's data on smartphone android application with low complexity, low power consumptions, and high portability. The system has an android application (user- friendly GUI) for consultant smartphones, an Android application Access Server, Database Server and the indigenously designed and developed patient monitoring system having real- time temperature and SpO_2 monitoring.

V. FUTURE WORK

In future, research work focuses to include more physiological vitals such as heart rate, Blood pressure, and ECG. Also, a local server can be established to store past and present history of patients so that Surgeons could have a quick analysis of all procedures and treatments patient has gone through.

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