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A Survey on Physiological Vital Signs Monitoring Using mHealth Application for ICU Patients

Parmar Bhavna C, Dr.Yagnesh B. Shukla

M.E. Student, Dept. of E.C., SVIT, Vasad, India

Professor, H.O.D, Dept of E.C. , SVIT, Vasad, India

ABSTRACT: Many devices have been developed over the year to monitor patient's vital parameters. However, most of them lacked portability, security, wireless connection and the ability to communicate with patient's computer and their doctors in case of emergency. This system represents smartphone based analysis proves to be efficient in scenarios when any patient can need any kind of immediate medical care .This system also adds the feature of android smartphone for the acquisition and analysis of multiple biomedical signals, including ECG, Blood pressure ,Heart rate , temperature etc. The novel approach of this system is mHealth appilaction for elderly people in ICU. mHealth helps organizations overcome the limitations caused by a lack of interoperability between systems and application in healthcare today. The sky is the limit for mhealth to improve patient care and improve outcomes. In this proposed system, doctor can monitor as well as manages the patient's critical condition and according to patients condition they get the immediate detoxified.

KEYWORDS: IoT, ECG Sensor ,SPO2, Heart Rate, Wireless Body Area Network.

I. INTRODUCTION

The fast lifestyle, the lack of time or living in a large city causes difficulties to take care about elderly family members. Disappearance of the multi-generational family model contributes to loneliness of elderly persons, who most often live alone. The analysis of Europe population shows that in the greater part of the continent almost one third of the people is aged over 65 years old and that trend is growing. Countries with high percentage of the elderly include inter alia Germany, Italy, Sweden, Finland and Greece. On the other hand, countries with younger society such as Poland, the Czech Republic and Ireland account for the small percentage of the overall Europe's population. Even in these countries in the next decades the number of young people will drastically decrease as compared to the elderly.[2]

Recent years have seen a rising interest in wearable sensors and today several devices are commercially available for personal health care, fitness, and activity awareness[6][3]. In addition to the niche recreational fitness arena catered to by current devices, researchers have also considered applications of such technologies in clinical applications in remote health monitoring systems for long term recording, management and clinical access to patient's physiological information. Based on current technological trends, one can readily imagine a time in the near future when your routine physical examination is preceded by a two–three day period of continuous physiological monitoring using inexpensive wearable sensors. Over this interval, the sensors would continuously record signals correlated with your key physiological parameters and relay the resulting data to a database linked with your health records[10]. When you show up for your physical examination, the doctor has available not only conventional clinic/lab-test based static measurements of your physiological and metabolic state, but also the much richer longitudinal record provided by the sensors. Using the available data, and aided by decision support systems that also have access to a large corpus of observation data for other individuals, the doctor can make a much better prognosis for your health and recommend treatment, early intervention, and life-style choices that are particularly effective in improving the quality of your health. Such a disruptive technology could have a transformative impact on global healthcare systems and drastically reduce healthcare costs and improve speed and accuracy for diagnoses.[8]

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II. RELATED METHODS

Fig. 1 System operating Steps[7]

The system operation is completed in five main steps as shown in Fig. 2. Here, two techniques are consider to implement the system.

Fig. 2 Technique I[7]

In the first technique we connect the sensors attached with the patient's body to a transmitter unit associated with a ZigBee or GSM network. The transmitter transmits the data wirelessly to a receiver that is also associated with a ZigBee or GSM network. The receiver is connected directly to the USB port of a local monitoring unit (which is a Laptop with LabVIEW software in it). The local monitoring unit displays the final data.

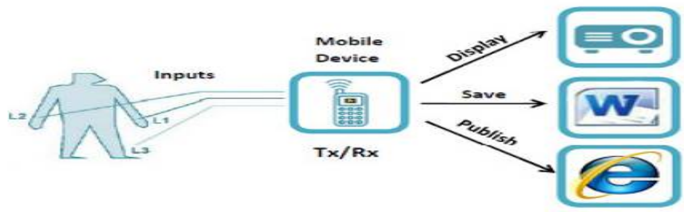

Fig. 3 Technique II[7]

In the second technique as shown in Fig. 4, we connect the sensors attached with the patient's body to a mobile device. The mobile device acquires the data from the sensors and sends them to a processor, which is running the LabVIEW software in it. The processor receives the data and performs the necessary analysis. It can display the data in an organized Graphical User Interface (GUI). The processor also saves the data in a worksheet associated with the Microsoft Excel program. Finally, it can publish the data in the Internet so that the healthcare professionals can monitor them from a remote location at any time.

WIRELESS BODY AREA NETWORK

Body area network or body sensor network is the wireless network consist of several body sensor units connected to the central unit which perform the signal processing and data analysis. Basically body area network consists of the BAN architecture and the communication protocol such as Bluetooth or Zigbee[2].

BAN Architecture

In this architecture the different sensor nodes performed the primary data processing, which includes the physiological signal processing in the microcontroller. The Android Smartphone performed the secondary data processing and shows the resulting output on the Graphical User Interface (GUI). This secondary data processing includes data filtering, data representation, graphical interface and data synchronization.

Finally, the most important data processing is done together with database management in the server. This medical server allows the secure local and remote access for medical professional using Internet.

In this design the Bluetooth is used as a communication protocol. Bluetooth is used to link the different sensors with the Android Smartphone. Also the power consumed by the Bluetooth is low.

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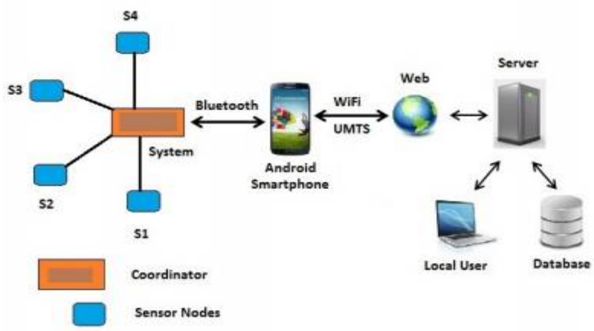

Fig. 4 Body area network or body sensor network[2]

The Bluetooth is standard IEEE 802.15 communication protocol for exchanging data over short distances from fixed and mobile devices. It works on the 2.45 GHz frequency band. Bluetooth operates on a very low power of 1.8 to 3.6 volts. It provides 3 Mbps data rate for distances of 20 meters, which is very good. The Bluetooth module is simple to use and fully certified, which provide the complete wireless embedded solution for short distances.

III. Measurement of Parameters

SPO2

To calculate SpO2 and heart rate, person's finger is inserted between the transmitter and receiver. A photo detector measures the light that is scattered through the blood tissues
using Red and IR LEDs. Based upon the ratio of absorbance
of the red and infrared light, a measure of saturated percentage of oxygen can be given as[5]

SpO2 ¼ ð110 _ 25 _ QÞ % ð1Þ

where Q is the ratio of maximum amplitude of pulsating Red wave (ACR) to the maximum amplitude of pulsating IR wave (ACIR) and is given as

$$Q = ACR/ACIR$$

Heart Rate

Heart rate is obtained when IR LED is ON and is given by[5]

Heart rate = number of pulses counted in 10 s*6

ECG

An ECG electrode is a device attached to the skin on certain parts of a patient's body — generally the arms, legs, and chest during an electrocardiogram procedure. It detects electrical impulses produced each time the heart beats. The number and placement of electrodes on the body can vary, but the function remains the same. The electricity that an electrode detects is transmitted via this wire to a machine, which translates the electricity into wavy lines recorded on a piece of paper. The ECG records, in a great detail, are used to diagnose a very broad range of heart conditions. An ECG electrode is usually composed of a small metal plate surrounded by an adhesive pad, which is coated with a conducting gel that transmits the electrical signal.[7]

IV. Algorithms

SpO2, heart rate and skin temperature is calculated. Schmitt trigger is used to convert the irregular waves of IR led to square wave for heart rate measurement and is given as input to microcontroller pin .The measured body parameters are then sent to the mobile phone. SparkFun Bluetooth Modem–BlueSMiRF Silver module has been used for transmitting data wirelessly from TXD1 pin of microcontroller.

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A. **Flow Chart for calculating body parameters**

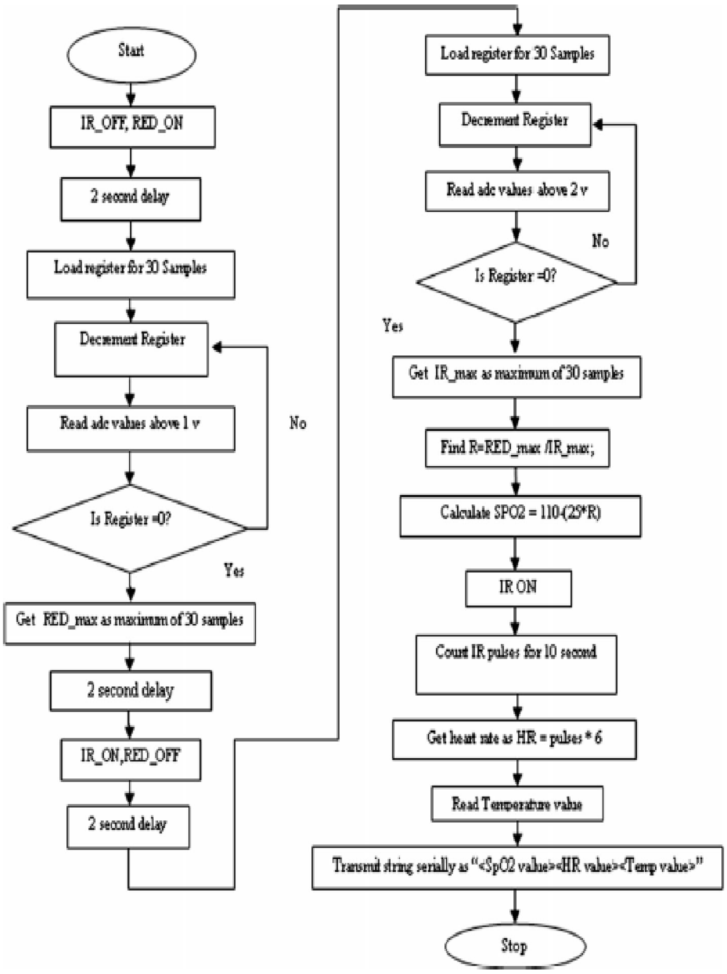

Fig. 5 Flow Chart for calculating body parameters[5]

B. **Flow Chart Of ECG Parameter**

The program flowchart shows the steps of the program for the system. The program starts by receiving the readings from the sensors connected to the patient's body through wires. The acquired data is then sent to the programming environment (i.e., LabVIEW Software). The program analyzes and displays the data regarding the body temperature, ECG and heart rate.

Finally, the data are saved and are also used to generate well-organized report by the system with respect to the time. It presents data regarding current day, date and time, ECG signal, QRS interval, heart Rate, blood pressure, and body temperature. A button located in the front panel can assist in retrieving previous data. This button is also linked to Microsoft word program to tabulate the previous results in an organized report that enables doctors and caregivers to follow patient's health status for the previous periods.[9]

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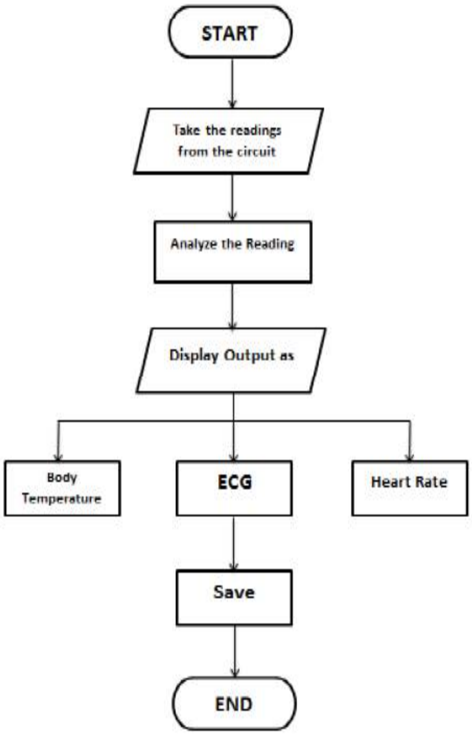

Fig. 6 Flow Chart Of ECG Parameters[7]

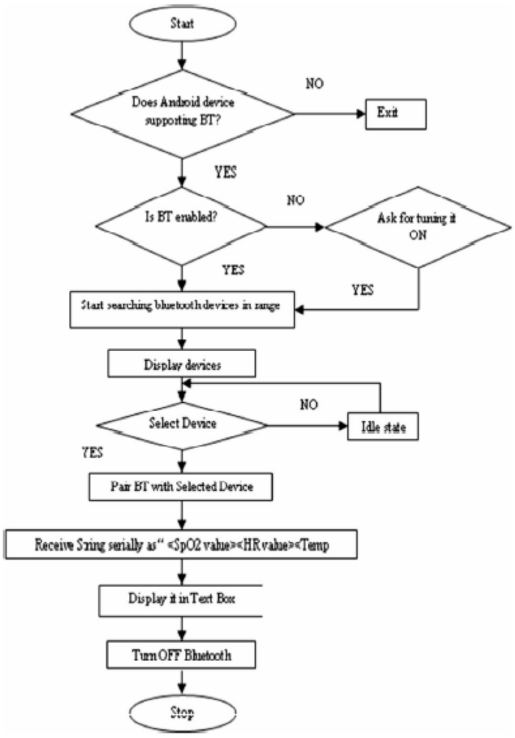

Fig. 7 Flow Chart of Application Development[5]

C. **Flow Chart of Application Development**

Smart phones are being used by many people these days and is becoming popular gadget than computers. In the proposed system, Android based platform has been chosen to develop the application as it is built on an open source framework. The implementation of Bluetooth technology in the system not only reduces the power consumption during longterm monitoring but also eliminates the physical constraints imposed by hard–wired link. Moreover, the measurement provided can be used in effective telemedicine services aimed in enhancing the user's well being and providing a better and more comprehensive healthcare services. When Heart Rate icon is selected, Bluetooth is turned ON by enabling the Bluetooth permission request. After the application is clicked to open, various buttons shown in Fig. 8 appear on the screen and the function of each button is described as follows:

- **Scan Bluetooth Devices**: This Button scans the available nearby Bluetooth devices and displays it at the bottom. In this case SPO2_1 Bluetooth device with MAC address 00:06:66:66:34:B8 is scanned.
- **Connect Device:** This button connects the scanned Bluetooth device with the Bluetooth of mobile phone.
- **Receive Data:** When clicked, this button starts receiving the data via Bluetooth protocol by opening Bluetooth communication socket. The values of heart rate, SpO2 and body temperature are displayed at the bottom of mobile phone.
- **Turn Off:** This button will turn off the Bluetooth of mobile phone.

V. TESTING RESULTS

Figure 8 shows the Absorption of oxygenated and non-oxygenated haemoglobin at different wavelengths. Figure 9 shows the scatter plot of body parameters by comparing the experimental results of standard instrument against prototype device in Microsoft excel.

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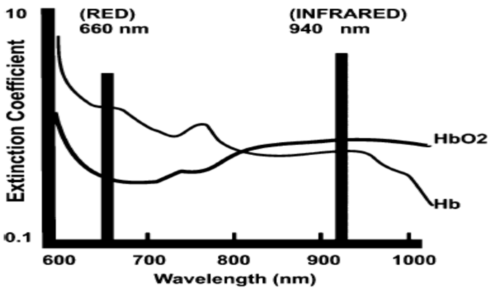

Fig. 8 Absorption of oxygenated and non-oxygenated haemoglobin at different wavelengths[5]

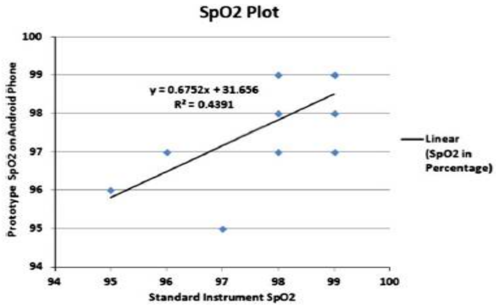

Fig.9 Saturated percentage of oxygen measured with standard equipment against prototype on Android Phone[5]

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correlation coefficient R measures the strength of a relation between the standard and prototype device. It shows that there is a perfect correlation for heart rate and skin temperature as the points in Fig. 10 and 11 lie almost along the straight line.

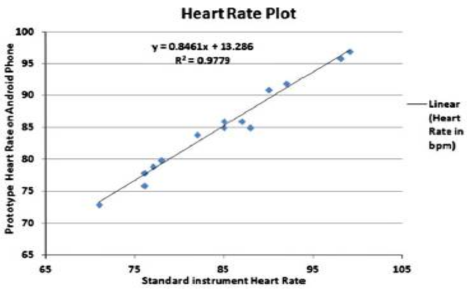

Fig.10 Heart Rate measured with standard equipment against prototype on Android Phone[5]

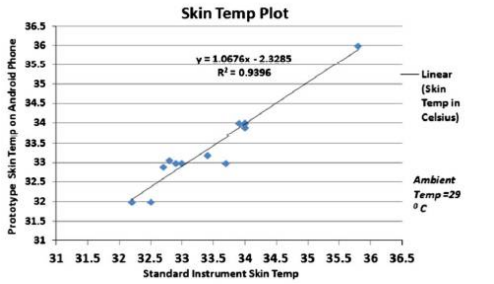

Fig .11 Skin Temperature measured with standard equipment against prototype on Android Phone[5]

VI. CONCLUSION

A smartphone based health monitoring system has been presented in this work. Wearable sensors, particularly those equipped with IoT intelligence, offer attractive options for enabling observation and recording of data in home and work environments, over much longer durations than are currently done at office and laboratory visits.This treasure trove of data, when analyzed and presented to physicians in easy-to assimilate visualizations has the potential for radically improving healthcare and reducing costs. By using the system the healthcare professionals can monitor, diagnose, and advice their patients all the time. The physiological data are stored and published online. Hence, the healthcare professional can monitor their patients from a remote location at any time. This system is simple. It is just few wires connected to a small kit with a smartphone. The system is very power efficient. Only the smartphone or the tablet needs to be charged enough to do the test. It is easy to use, fast, accurate, high efficiency, and safe (without any danger of electric shocks). Finally, the reliability and validity of this system have been ensured via field tests. The field tests show that this system can produce medical data that are similar to those produced by the existing medical equipment.

VII. FUTURE ENHANCEMENT

This App. can be enhanced further by having an alert system which regularly reminds the user to check his/her temperature. The user can store this information in the database. We can also include the functionality of sending an SMS to the users' family doctor about the patients' medical condition. A graph can also be plotted on a day-to-day basis.

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