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# Smart Patient Monitoring System for Emergency Situations

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**Abstract—***Continuous patient monitoring systems have drawn significant attention in the last two decades. A large number of cost-effective versions of patient monitoring systems are available, which were being utilized by authorized health care professionals. In addition to this there is a strong need for web based patient monitoring system, when the patient is not in the hospital. The main objective of this paper is to design and implement a low cost, portable effective patient monitoring system that can transmit the vital signs of a patient in emergency situation continuously through a wireless communication network system. Various sensors such as pulse, temperature, blood pressure and fingerprint are interfaced with the microcontroller for measuring the important physical parameters of a patient. For wireless transmission, these sensors are connected to a sensor node through GSM module. Raspberry-Pi is used as a sensor node as it has better features compared to the other controllers. After connecting Internet to the Raspberry Pi board it act as a server. Then the server routinely sends measured data to the webserver , which are further monitored using webpage anywhere in the world using laptops, android smart phone etc. The measured real time parameters are updated every 30 seconds. The data acquired is first stored, analyzed and visualized on a webserver. The system is implemented in such a way that, when the measured physiological data exceeds the certain threshold values, the caretaker is alerted through SMS and a voice call. Also using the proposed system, real-time remote monitoring is also carried out on the patient. Additionally, locational data obtained from GPS receiver is shown on the digital map and sent to the related units. Thus, the proposed system makes the human's daily life relaxed and more comfortable.*

## 1. INTRODUCTION

With an increase in the number of elderly people throughout the world in many countries, there is a concern about their health. This has led to a crucial requisite for devising cheaper and smarter ways to design health care systems for elderly people suffering from various diseases. According to a health report from the World Health Organization (WHO), the problem of population aging is becoming more serious. Health conditions of aged people need to be checked more frequently, which poses a greater challenge to existing medical systems. Consequently, to categorize and identify different diseases in human body in time and accurate manner with low costs has been paid an increasing attention in the past decade. Also, it has been perceived that whenever an individual is exposed to longer working hours, it typically leads to weakness. If this situation is unattended by the doctor, then this might lead to other complications such as heart diseases, brain diseases and sometimes even cause a major drop of oxygen levels in the body. Finally the health situation eventually becomes a serious issue for that person. Likewise, a huge number of individuals who are exposed to destructive environments die due to cardiovascular diseases every year. The present world population also has an increase in the number of aged people who seek health care systems. Current developments in sensor fabrication, high speed communication systems and information technologies have enabled the improvement of novel vital signs monitoring systems by which various vital health parameters can be measured, like body temperature, heart rate, electrocardiogram (ECG), blood pressure and oxygen saturation [1]-[2]. In particular, wireless healthcare related applications using wireless sensor networks may support people and caregivers by providing non-invasive and invasive continuous health monitoring with a minimum interaction of doctors and patients.

Wireless sensor networks (WSNs) are finding numerous applications in wide areas, such as health monitoring and controlling, emergency response, environment and agriculture, security, industrial automation, seismic detection, infrastructure protection and optimization, automotive and aeronautic applications, building automation, and military applications [3]-[4]. A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes. The data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks like wireless Ethernet. It consists of base stations and numbers of nodes (wireless sensors).These networks are used to monitor physical or environmental

conditions like sound, pressure, temperature, any other physical quantities and compliantly pass the acquired data through the network to a main server.

A wireless sensor network can be composed of a large number of nodes, constituting a multi-hop network, where vicinity nodes communicate with each other, with routing responsibilities. Advances in wireless communication and micro electro mechanical systems (MEMS) allow the establishment of a large scale, low power, multi-functional, and low cost network. Since a wireless sensor network can have many sensing nodes, they have advantages over traditional sensing methods like increase in the robustness, fault tolerance and increase in spatial coverage. A wireless sensor network can be easy to deploy in any environment, and the physical information is gathered, processed and sent to the central server located nearby.

However, there are some significant inconsistencies, such as node lifetime, packet recovery and medical data collection between existing wireless sensor networks and those required for healthcare. In addition to the basic requirements of being wireless, a future healthcare system based on wireless sensor networks must have support for ad-hoc networks, the mobility of patients or elderly persons, wide ranges of data rates and a high degree of reliability. Also, the designed systems need to be smaller in size, should be easily wearable by themselves and should have lesser weight, thus causing the least inconvenience to the patients. Some of the drawbacks of WSN are that they are not much secure when compared to wired networks and hackers can easily intrude the network, circuit nodes need to be charged at regular time intervals, communication speed is comparatively low less than the wired type of network and WSN devices gets distracted by other wireless devices. The design of a WSN is application-specific, and different applications have different reliability requirements. Reliability of data communication is an important factor for the dependability and quality-of-service (QoS) in various applications of wireless sensor networks. In particular, this is applicable for the case of critical care applications of hospitals that allow the continuous monitoring of a patient's important parameters. The sensitivity of various sensors used for the measurement, the sampling rate of the analog to digital converter, the number of nodes in the same network and data packet sizes are very important parameters in the design of patient monitoring system.

The main objective of this work is to measure various physiological parameters of human body such as body temperature, heart or pulse rate, respiration rate and blood pressure. The measured physiological data from various sensors are interfaced to Raspberry Pi boards. The data from the Raspberry Pi is coupled to GSM module, where it is communicated to the doctor data in order to be subsequently analyzed for medical diagnosis, using an android application, web services and multi-protocol unit [6]. This patient monitoring healthcare system advises and alerts in real time the doctors/medical assistants about the changing of very important vital parameters of the patients and about important changes in surrounding environmental parameters, in order to take preventive measures, save lives in critical care and emergency situations.

This paper is organized as follows. Section II presents the design and implementation of the proposed system using Raspberry Pi 3 B model. Section III explains the working of the system and its flowchart. The hardware prototype implementations are presented in Section IV. Finally, conclusions are drawn in Section V.

## 2. DESIGN AND IMPLEMENTATION OF THE SMART PATIENT MONITORING SYSTEM

A sensor is actually a device installed or interfaced in a system. Using a wireless technology, the measured physiological data is sent back to the system for interpretation and analysis or even send its response to an actuator. Implementation of an efficient patient monitoring system depends on various parameters such as heartbeat, blood pressure, body temperature, saline level, patient position, airflow, etc. Alteration to these parameters by the body reactions resulting abnormal functioning of the responsible organ might cause to serious dangers to health of a patient and hence need regular monitoring to avoid these fatal conditions [7].

The proposed implementation of an efficient health monitoring system is shown in figure 1. It consists of a transmitter section and the monitoring section. The transmitter section consists of a Raspberry Pi 3 B Model, various sensors such as pulse sensor, blood pressure sensor, temperature sensor, finger print sensor, GSM Module, Zigbee, Liquid crystal display and camera. The monitoring section consists of Zigbee receiver, personal computer or laptop, LED, buzzer and an android smart phone.

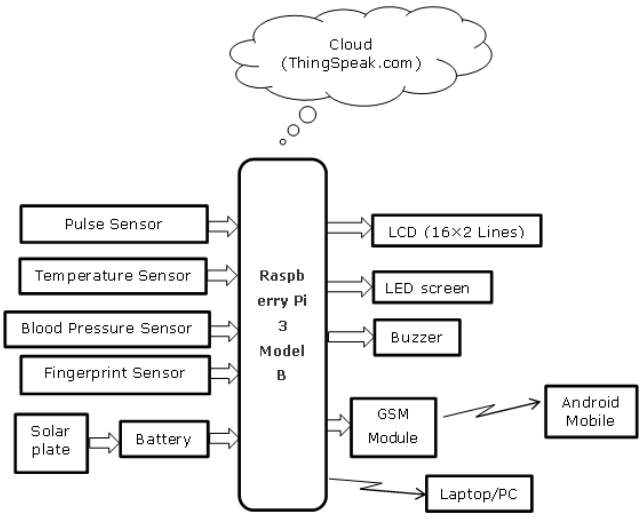


**Figure 1: Block diagram of the Patient monitoring system**

The proposed system is able to sense to parameters in real time and displays them on different indicating output devices which enables the doctor to monitor the patient's health parameters (such as heartbeat, blood pressure, temperature, etc.).

The proposed system consists of the following main hardware:

**2.1 Raspberry Pi 3 B model:**

The recommended Raspbian operating system for the proposed work is the Raspberry Pi 3 B Model. It is an open-source based on Debian, optimized for the Raspberry Pi hardware implementation.

**2.2 Pulse sensor:**

A pulse sensor is designed to give a digital output of the heart beat (which ranges between 60 to100 BPM for adult and 80 to 100 BPM for children) when a finger is suitable placed on it. It works on the principle of light modulation (with the help of infrared rays) by blood flow through a finger for each pulse.

**2.3 Blood Pressure sensor:**

The proposed system uses a cuff-less blood pressure sensor which is based on transit time, interval time required for a pressure wave in the arterials to travel between two sites. It is a convenient, easy-to-use relatively cheap and fast for detecting blood pressure normally more than 120 over 80 and less than 140 over 90 (120/80 – 140/90).

**2.4 Temperature sensor:**

The normal human body temperature is about 37°C and it is very important as far as health monitoring is concerned. The LM35 Human Body Infrared Temperature sensor is used in this system which working. It is a precision integrated circuit temperature sensor and its output voltage and Celsius temperature are linearly proportional with its operating range from -55°C to +120°C.

**2.5 Finger Print sensor:**

Access to patient's database should be confidential and a fingerprint sensor/scanner can help prevent unauthorized personnel from accessing the monitoring system. An ultrasonic pulse is transmitted against the placed finger on the scanner thereby accepting or denying access to the monitoring system. Hence, only the doctor and nurses working in the hospital should be granted access to the system.

**2.5 GSM module:**

A GSM Module is used to set up a communication between the doctor's mobile phone and the patient parameters measured. This has a significant improvement to the previous implemented systems where the doctor needs to be physically present to monitor patients tied to their hospital beds. The GSM module is programmed to convey the measured parameters to the doctor's mobile phone through a configured SIM.

## 3. FLOW CHART AND ALGORITHM

The flowchart of the proposed smart patient monitoring system for emergency situations is shown in figure 2. The entire sequence of events is explained as shown below:

Step 1: Start

Step 2: Scan finger

Step 3: If the scanned finger is recognized, go to step

4; else go to step 2

Step 4: Establish a connection between

Microcontroller, GSM Module, network, and cloud server

Step 5: Continue to read sensor data from patient

Step 6: If the sensor data are greater than the sensor threshold limits, go to step 7 else go to step 5

Step 7.1: Display the alert on an Alarm & LCD

Step 7.2: Notify the Doctor about the patient condition either by SMS or call to his Android mobile.

Step 7.3: Upload the data changes to the cloud server.

Step 8: Stop

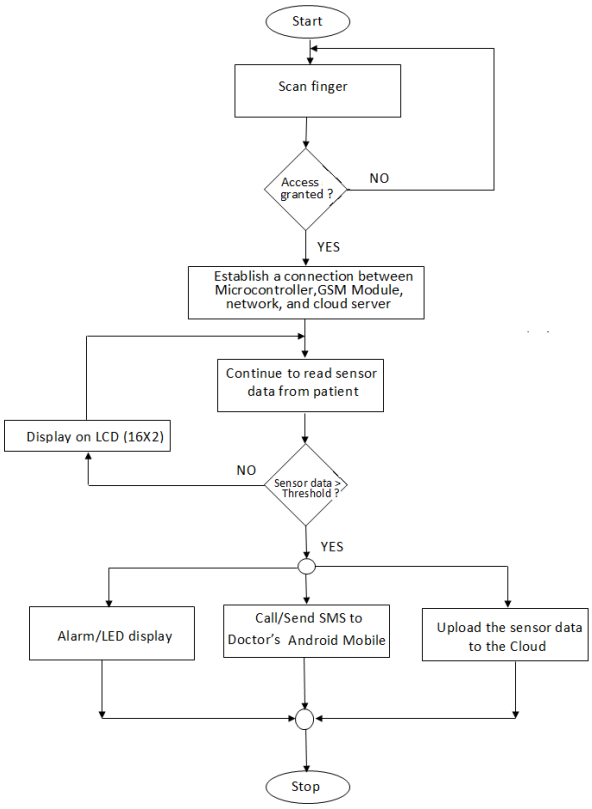


**Figure 2. Flow chart of the entire process**

## 4. HARDWARE IMPLEMENTATION

The main microcontroller used in this proposed is the Raspberry Pi 3 Model B. All the different sensors such as the pulse sensor, temperature sensor, fingerprint sensor and blood pressure sensor are interfaced with it. The GSM module and Zigbee are also interfaced with the Raspberry Pi 3 Model B through wire interconnections and programmed located at the patient hospital bed. The fingerprint sensor is interfaced with the Raspberry Pi 3 B Model so as to grant access only to the doctor/nurse and not some other physician. This patient monitoring system can be efficiently implemented remotely by the doctor at the receiver end by using right commands at the laptop end. When powered and programmed, independent and precise operations of reading the patient parameters such as blood pressure, patient heartbeat and patient temperature and sending the sensed data to the doctor's android phone, PC as well as making an alert like blinking an LED, sounding of a buzzer or displaying the abnormality on LCD will be taken by the system to call attention of the doctor. This will quickly call the attention of the assigned doctor/nurse thereby saving the patient's life. The final hardware prototype of the smart patient monitoring for emergency situations is shown in figure 3.

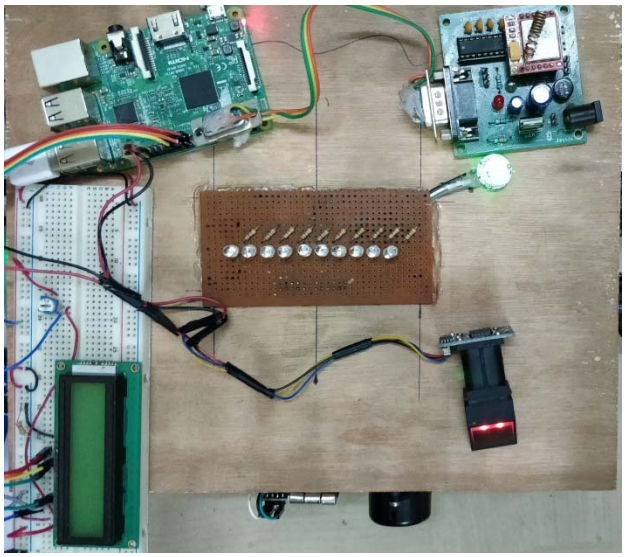

**Figure 3. Prototype of the patient monitoring system**

The glowing of LED lights in figure 4 indicates the presence of high blood pressure. The threshold measurement for blood pressure measurement has been set at (130/88). If all the LEDs glow, then it indicates the patient is suffering from high blood pressure, and therefore immediate attention need to be carried out by the doctor.

The measurement of various important parameters is shown in figure 4, while the screenshot of the received SMS message on doctors mobile is shown in figure 5.

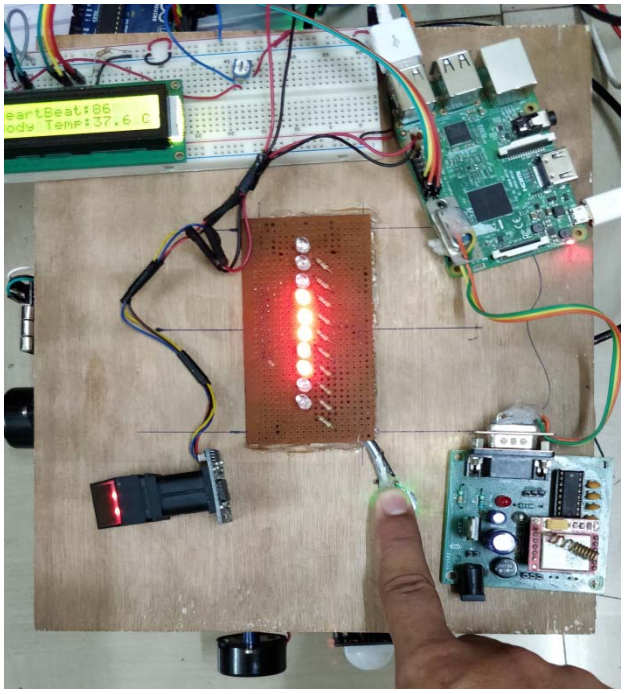

**Figure 4. Measurement of temperature, heartbeat and blood pressure**

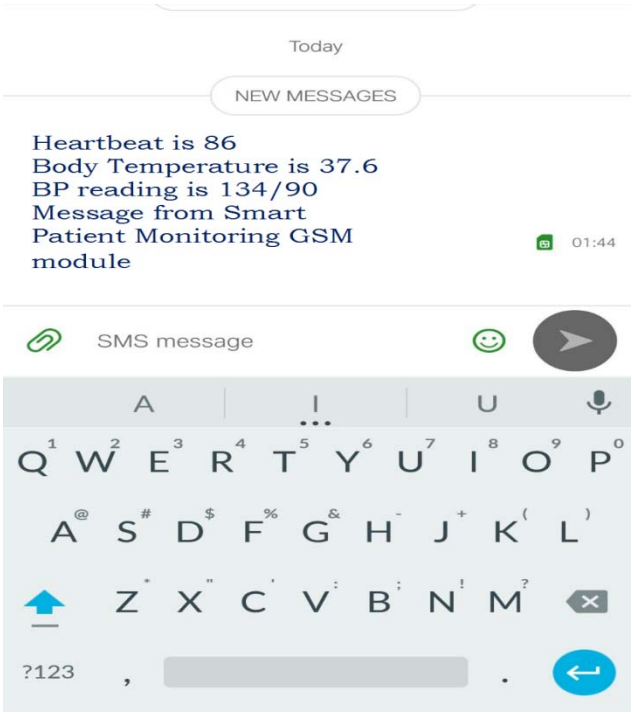


**Figure 5. SMS message received on android mobile**

## 5. CONCLUSION

In this paper, the design and implementation of smart patient monitoring system for emergency situations is presented. The main objective of the proposed work is to measure different important physiological parameters of human body such as body temperature, heart or pulse rate, respiration rate and blood pressure. This system helps patients to consult anywhere doctors, and doctors to follow up patient's requests and data. Various sensors such as pulse, temperature, blood pressure and fingerprint are interfaced with the microcontroller for measuring the important physical parameters of a patient. It uses wireless sensor networks and information communication technologies to provide remotely clinical healthcare. The measured real time physiological parameters are updated every 30 seconds. The data acquired is first stored, analyzed and visualized on a webserver. The system has been designed in such a way that, when the measured physiological data exceeds the certain threshold values, the caretaker is alerted through SMS and a voice call. The main advantage of the proposed system is the reduction of the intervention time of the patient in an emergency situation. Accordingly, the proposed low-cost system saves lives in critical care and emergency situations.

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