

Development of Personal Health Monitoring and Rapid Response System for aged People (PHMRRS)

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ABSTRACT: Old age is one of the unavoidable phase of human life. Because of age factor, such people not only require constant monitoring of the health related physiological parameters like blood pressure, heart rate, body temperature etc but also detection & notification of fall. Fall is a physical phenomena for which these elderly people are most prone. The research in the field of telemedicine or wireless healthcare (Medical) monitoring system has become one of the important topic because of the development and popularization of information processing and wireless data transmission techniques with biomedical sensors are increasingly becoming popular. Today people use their smart phones not merely for communication but also to monitor their health conditions. Monitoring of Physiological parameter is a very complicated work and its accurate measurement & control can save the people if timely remedial assistance is provided. Human physiological parameters such as blood pressure, heart rate, rate of respiration, ECG & body temperature are important parameters which are required to be monitored continuously. Researchers have used available latest techniques for monitoring these bio-vitals either as a single entity or multiple. But a standard, low cost, 51 architecture GSM & GPS based complete comprehensive system to monitor all bio vitals with fall detection and notification is the necessity of the present scenario. Hence, this paper proposes 51architecture microcontroller based low cost real time Personal Health Monitoring and Rapid Response System (PHMRRS) for aged people. This system includes monitoring of blood pressure, body temperature, heart rate and fall detection & notification techniques. The system is supported with GSM & GPS technologies. The GSM architecture is for information transformation through SMS and GPS is for location awareness. For clinical trials, the system was tested in the hospital for different age & weight people. Finally, we compared these results with readings taken by Doctor with traditional instrument. The developed system is aimed at aged or elderly people, as the movement of these people is restricted because of health/age factor. This complete system is the combination of latest technologies in a single module, fulfils the requirements of delivering critical information to concerned people or medical experts.

KEYWORDS: Bio-vital Sensor, Microcontroller, Physiological parameters, GSM and GPS.

I. INTRODUCTION

Health is major concern to humanity. World Health Organization says health is a fundamental right for an individual to attain the highest standard on the globe. The population of aged people and their chronic diseases increasing, the need for constant medical assistance for such people is also increasing. The latest wireless communication technologies & monitoring network that not only helps the medical experts to provide excellent treatment and comforts to the patient but also regulates the method of therapy based on the bio-vital data. Tele medicine or mobile healthcare is the integration of mobile computing & health monitoring. ICU's are the excellent places for continuous monitoring of patients, a modern

International Journal of Innovative Research in Science, Engineering and Technology

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health monitoring system must provide better health care services to the people at any time & from anywhere in an economic & patient friendly manner. But in these ICU's, patients are totally covered with monitoring, measuring & treatment equipments and connectors (probes) etc, due to which it will not only hinder the nursing staff but also restrict the movement of the patient. Today, the health care systems are passing through a cultural shift from a traditional approach to a modern patient oriented approach. Measurement of Physiological parameters of a patient is a most basic function of medical experts. The main bio-vital signs which are routinely monitored by the medical experts are body temperature, heart rate and blood pressure.

Standard Physiological parameters: All the bio vital signs should have a standard values according to medical science, they are 1) **Human body temperature:** Temperature is a measure of the degree of heat intensity. The human body's core temperature varies from day to day, and from time to time, but these fluctuations are small, usually not more than 1.0°C. Humans are homoeothermic and body temperature is regulated at about 37°C ±1°C. 2) **Heart rate:** Heart rate is the number of heartbeats per unit of time, typically expressed as beats per minute (bpm). Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide during physical exercise, sleep, illness, or as a result of ingesting drugs etc in which the heart rate speeds up or slows down. **Tachycardia** is a resting heart rate more than 100 beats per minute. This number can vary as younger ones and children have faster heart rates than average adults. 2) **Bradycardia** is defined as a heart rate less than 60 beats per minute although it is seldom symptomatic until below 50 bpm when a human is at total rest. 3) **Blood Pressure:** Blood pressure (BP), sometimes called as arterial blood pressure, is the pressure exerted by circulating blood upon the walls of blood vessels, and is one of the principal vital signs. During each heartbeat, blood pressure varies between a **maximum (systolic)** and a **minimum (diastolic)** pressure. A person's blood pressure is usually expressed in terms of the systolic pressure over diastolic pressure and is measured in millimetres of mercury (mmHg), for example 120/80. **Non Invasive Blood Pressure (NIBP)** measurement method is adopted by this system to measure the Systole and Diastole pressure values. The following table shows the standard values of all the physiological parameters.

Table 1: Standard Physiological parameters values

Sl. No	Physiological Parameters	Standard Values
1.	Blood Pressure in mmHg	Diastolic(low) = 80, Systolic(High) = 120 in mmHg [For adults above 12 years]
2.	Heart Beat/Rate in bits per min	Bradycardia(low) = 60, Tachycardia(high) = 100 [For adults above 12 years]
3.	Body Temperature in Centigrade/Fahrenheit	36.5 to 37.5 deg C or 97.7 to 99.5 deg F

II. RELATED WORK [LITERAURE SURVEY]

The literature survey shows that, modern technologies for control & measurement of bio-vitals have been used by the researchers. Also employed wireless devices/sensors, fall detection methods and advanced communication techniques for this purpose. M.V.M Figueredo et.al suggested the use of the telemedicine system using mobile telephony in which wireless sensors collects the data and sends through RS232 to a server with internet facility for physiological parameter monitoring [1]. P.S Pandian et.al proposes the wireless sensor network for variety of bio sensors and its adaptability to wearable physiological monitoring system using personal area network [2]. Piyush V. Savaliya et.al mentions the advantage of use of short distance communication method such as Bluetooth for measurement of human physiological signals based on FPGA method [3]. M. Vinaykumar et.al makes use of ARM controller with GSM communication

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technique for collection & transmission of bio-signals wirelessly on a cell phone [4]. Sriram K Vasudevan et.al checks the feasibility of Zigbee communication technique which collects & transmits the bio signals to a PC, so that within the premises of the hospital doctor can monitor the patient [5]. Priya. M et.al proposed PIC based wireless ICU monitoring system that uses Zig-bee protocol. Wireless sensors collect the data and Zig-bee is used to transmits these data to a PC through RS232 so that doctor can monitor patient's vital information on his PC remotely [6]. Rifat Shahriyar et.al used intelligent mobile health monitoring system by using a combination of technologies such as wearable body sensor network, patient's personal home server and an intelligent medical server for monitoring various physiological parameters [7]. Amna Abdullah et.al has developed a real time wireless health monitoring system using Zig-bee communication protocol with lab-view software for recording human bio signals [8]. S. Elango et.al suggests the development of an in-home healthcare system for monitoring health related bio signals using Wireless Sensor Network module with Lab-VIEW which sends the medical data to WSN gateway through wireless media [9]. Ping Wang et.al implements physiological parameter monitoring system for in-patient which has two parts one is patient physical state data acquisition module and the other is Zig-Bee module [10].

V. Ramya et.al developed a device which will continuously monitors the vital parameters of multiple patients with data logging facility using PIC microcontroller & GSM techniques [11]. D.J.R. Kiran kumar et.al reports about a real time portable health monitoring system built on programmable system on chip (PSoC) which has a zigbee communication module sends all the physiological data to a PC from which doctor can access the data on his PC [12]. Archita Agnihotri et.al., mentions the use of GSM communication technique for sending the acquired physiological data to cell phone of medical professional, the system collects all data with reliable sensors and sends on GSM network [13]. Neeta V Desai et.al developed a health monitoring system which continuously monitors bio vitals of a in-home patient using wireless non-contact radio frequency electromagnetic fields to transmit & receive the signals [14]. Johevajile K.N et.al designed & developed a non invasive, accurate low cost biomedical sensor interface for processing bio vitals such as blood pressure & body temperature and checks its accuracy with simulated circuits using mat lab [15]. P. Karthick et.al suggests a wireless health monitoring system that uses variety of biosensors for sensing the human bio vital signals, the acquired data is transmitted through ZigBee transmitter & it is collected at ZigBee receiver [16]. Gunalan M.C et.al., also suggests the use of ZigBee protocol for communicating acquired bio vitals to a PC which acts as a central monitoring system which uses Lab View software [17]. Kalpana P.M et.al., authors to use PIC microcontroller based wireless embedded system for human health monitoring in which data collected form the nodes are transmitted to ZigBee transmitter in turn to a PC which is connected to network wherein data is stored, displayed and retrieved [18]. Ch. Srikanth et.al., developed a smart embedded medical diagnosis unit using ARM core based beagle-bone black with Adriano platform which provides a integrated development environment for monitoring personal health [19]. This paper proposes a low cost 51 architecture microcontroller based embedded system that monitors the human physiological parameters with low cost liquid based fall detection & notification. The developed system makes use of GSM & GPS network to transmit this vital information & location awareness. It also compares the values recorded from the developed system under clinical trials with the values recorded by doctor with traditional methods.

III. THE SYSTEM OUTLINE

The proposed system ia based on 51 architecture family of microcontroller for personal health monitoring and rapid response system (PHMRRS) along with fall detection & notification techniques by the use of GSM & GPS. The system uses high sensitive LM-35DZ temperature sensor for measurement of human body temperature. The other physiological parameters like blood pressure & heart rate is measured by OMRON make digital NIBP unit. The proposed system makes use of GSM technology & its functionality for mobile communication to transmit the physiological information to an authorized person's cell phone. The system has GPS technology for location identification in case of fall is occurred. The system has additional functionality to responds to SMS sent by the caretaker/doctor, verifies the authenticity and then sends a reply SMS with which it is possible to know the status of physiological parameter of concern person. The system is very rigorously tested in the hospital for clinical trials. Then we compared these values with the values of traditional apparatus taken by Doctor.

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IV. METHODS AND MATERIALS

Fig.1 shows the functional block diagram of the proposed systems. The system is built on Atmels 89c52 Microcontroller. The other components are LM-35DZ temperature Sensor, NIBP module, GPS receiver, GSM modem, Liquid based fall detection system, LCD display unit, ADC, physiological parameter setting knobs etc. Many of the components are common for a normal embedded system. We will discuss few components in brief in the following sections.

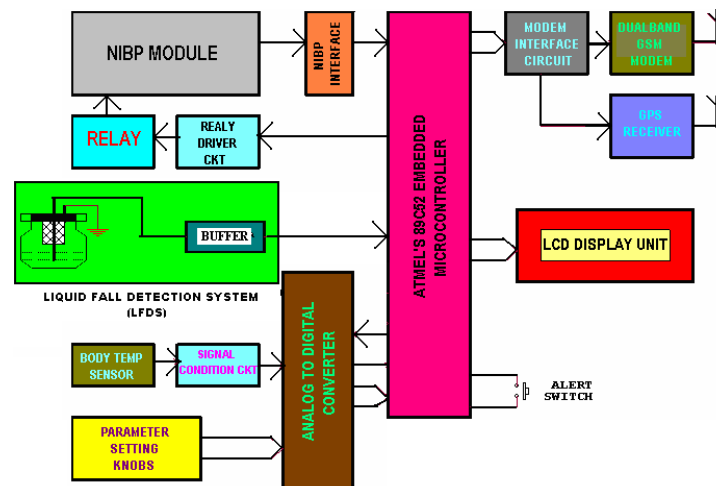


Fig. 1. Functional Block Diagram of the systems

1. Non Invasive Blood Pressure Module (NIBP)
2. Dual Band GSM Modem.
3. GPS Receiver
4. LM-35D Temperature Sensor
5. Liquid based Fall Detection System (LFDS)
6. Physiological parameter settings Knobs
7. Emergency Switches

A. NON INVASIVE BLOOD PRESSURE MODULE: OMRON NIBP module (HEM7111): - This is Blood Pressure measuring module. It has a pneumatic pressure pump and an external inflating rubber cuff and a strain gauge based pressure measurement sensor. When it receives the command from microcontroller, this module slowly inflates the cuff and senses the pressure in the cuff. After the pressure goes above the systolic pressure, it records this value and after that it starts to deflate the cuff. After the pressure goes below the diastolic pressure, it records this value also. In the mean time it also counts the heart rate by sensing the pulsations in the pressure. The microcontroller sends commands and extracts the values of systolic pressure, diastolic pressure & heart rate counts from this module through the serial RS-232 port link as shown in fig.2. This module is used to measure blood pressure & heart rate.

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Fig. 2. Image of OMRON NIBP Module HEM-7111 (courtesy Omron)

B. DUAL BAND GSM MODEM: This is a wireless MODEM, it can send & receive data through the GSM network. This modem requires a SIM card and connectivity to the GSM network. It has built in TCP/IP stack. The GSM MODEM communicates with the embedded microcontroller system with the help of AT commands. It works with two frequencies i.e. 900 MHz and 1800 MHz for up-linking and down-linking. Therefore it is a Dual band GSM MODEM. It is designed to work on RS232 standard, hence, while connecting to microcontroller, a RS232 to TTL level converter is essential.

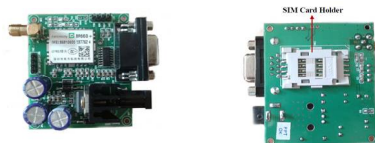


Fig. 3. Top View

Bottom View

C. GPS MODEM & GPS RECEIVER: It is a network of satellites that transmit coded information, due to which it is possible to accurately identify locations on earth by measuring distance from the satellites, is called GPS. They are capable of sending information through a simple serial link. The GPS Receiver which is used in this system will receive the coordinates needed from the GPS satellites and then send the information to the microcontroller. Because of its compactness in size & low power consumption, it is used in many embedded portable devices. It is having the ability to refresh its data once every second and therefore will be continuously updating the coordinate values for the microcontroller as the person changes location as in fig.4



Fig. 4. GPS Modem

GPS Receiver

Subscriber Identity Module: It is main feature of GSM. It is a detachable smart card containing the user's subscription information and phonebook due to which connectivity can be established with the network.

Short Message Service (SMS): It is very important service of GSM and is widely used by mobile phone users as a cheap and convenient method of communication through text. Since SMS technology is a cheap, convenient and flexible

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way of conveying data, Hence, many of wireless embedded system designers adapts this method for remote monitoring and controlling various parameters.

D. TEMPERATURE SENSOR (LM-35DZ): LM35DZ temperature sensor is used for this work. It is a low cost sensor used in industry and medical application. It is an industry standard semiconductor transducer, suitable for the temperature range of -50°C to $+150^{\circ}\text{C}$. It is a direct voltage o/p device. It produces $10\text{mV}/^{\circ}\text{C}$ of surrounding temperature. This voltage is amplified to make it suitable for the ADC to sense and for calibration. Since the output of sensor is $10\text{mV}/^{\circ}\text{C}$. The resolution of the ADC is 20 mV. Hence the signal is amplified precisely twice. It is used to measure body temperature as shown in fig 5.

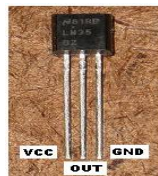


Fig. 5. Image of Temperature Sensor-LM35DZ

E. LIQUID BASED FALL DETECTION SYSTEM (LFDS): Liquid based tilt sensor is used to sense fall of the patient as a low cost approach. It is attached to the patient's body and is kept in upright position. It consists of a glass bottle filled with a conductive fluid and two electrodes, an inner electrode and the outer electrode. The outer electrode is in the form of a wire mesh and the inner electrode is a straight wire. The inner electrode is longer than outer electrode and is always in contact with the fluid. The fluid level in the bottle is so adjusted that it touches both electrodes only when it is considerably tilted. The following parameters have obtained after the calibration to detect the fall. Bottle length = 5.7cm, Outer diameter = 3.2cm, Total volume of the conductive liquid = 25ml & volume of the liquid at the sensor level = 14ml. The fall is categorized in two types i.e. REAL FALL & VIRTUAL FALL. According to human body posture, the real fall is one when the body touches horizontally to the plane of the ground. The virtual fall is simple bending of the body. To detect the fall angle an apparatus is designed with a bi axial mechanical accelerometer in our laboratory & it is shown in fig 6 & the identification of occurrence of fall at particular fall angle shown in table discussed as below.



Fig. 6. Shows bi-axial mechanical inclinometer for fall angle measurement & right image shows 24 deg fall angle

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Table 2: Fall sensor status for different angles taken by Liquid based Sensor

Angle of Tilt	Fall Sensor Status
0 deg	NO (FS=0)
5 deg	NO (FS=0)
10 deg	NO (FS=0)
15 deg	NO (FS=0)
20 deg	NO (FS=0)
24 deg	YES (FS=1)
30 deg	YES (FS=1)
35 deg	YES (FS=1)
40 deg	YES (FS=1)
45 deg	YES (FS=1)

Whenever the patient fall occurs, the bottle is tilted abnormally, it sends a signal to microcontroller, this microcontroller in turn sends SMS with FS=0 or FS=1 with the help of GSM network. The GPS sends geographical position of the device on the earth with longitude & latitude, so that location awareness can be identified properly.

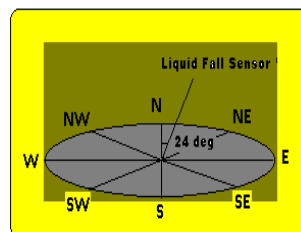


Fig. 7. Graphical representation of fall angle

F. PHYSIOLOGICAL PARAMETER SETTINGS KNOBS: These are potentiometers which facilitate to set the initial values of the physiological parameters. This facility is given to the doctor to set the initial values of a particular patient, as the doctor himself knows these values very accurately if he monitors ones or twice. Any abnormalities in the set values will be reported to doctor immediately through SMS.

G. EMERGENCY SWITCHES: It is a push button switch. In case of emergency, if the patient presses this emergency switch, the system becomes active, takes the readings and sends the message to doctor with fresh bio-vital information.

V. SYSTEM SOFTWARE

The proposed system is a dedicated embedded system which is based on 51architecture; hence, software was written in assembly language without using any general operating system & it is stored in the memory of the controller. The assembly language programming also reduces the code size, which is the main restriction when 51architecture is used. When power is switched ON the system comes to ON condition from RESET position then the program is executed and controller freshly takes readings for local display on LCD with and also sends SMS to doctor.

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VI. EXPERIMENTAL RESULTS & DISCUSSIONS

The designed system was taken to the hospital for clinical trials. Initially the Casualty Medical Officer (CMO) of the hospital to recorded the physiological parameter readings of 10 different ages & weight with traditional apparatus like mercury thermometer, Sphygmomanometer etc. Then the developed instrument is used to monitor & record the data of the same 10 patients and collected the readings. The values are shown in table.

Table 3: Comparison of Physiological Parameters

READINGS TAKEN BY CASUALTY MEDICAL OFFICER WITH TRADITIONAL INSTRUMENTS

Sl. No	Subject Identity	Weight In Kg	Blood Pressure in mmHg		Heart Rate (Pulse) in bpm	Body Temperature	
			Systolic (High)	Diastolic (Low)		In Deg C ⁰	In Deg F ⁰
1	Patient-1	68	140	80	88	36.6	97.82
2	Patient-2	47	100	60	102	37.7	100.0
3	Patient-3	55	100	60	78	35.7	96.26
4	Patient-4	72	136	94	80	37.5	99.50
5	Patient-5	67	110	70	72	36.0	96.80
6	Patient-6	75	152	84	79	36.2	97.16
7	Patient-7	40	135	76	84	37.0	98.60
8	Patient-8	48	115	85	98	35.8	96.44
9	Patient-9	78	145	92	88	36.4	97.52
10	Patient-10	65	108	82	73	36.9	98.42

READINGS TAKEN FROM DEVELOPED INSTRUMENT

Sl. No	Subject Identity	Weight In Kg	Blood Pressure in mmHg		Heart Rate (Pulse) in bpm	Body Temperature	
			Systolic (High)	Diastolic (Low)		In Deg C ⁰	In Deg F ⁰
1	Patient-1	68	150	83	93	37.0	98.62
2	Patient-2	47	110	70	96	38.0	100.43
3	Patient-3	55	108	67	73	36.0	96.82
4	Patient-4	72	142	99	85	38.0	100.43
5	Patient-5	67	104	75	68	36.0	96.82
6	Patient-6	75	155	88	82	36.0	96.82
7	Patient-7	40	130	78	81	37.0	98.62
8	Patient-8	48	120	82	95	36.0	96.82
9	Patient-9	78	150	96	83	37.0	98.62
10	Patient-10	65	110	85	76	37.0	98.62

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Finally, we compared the readings taken by the CMO & the readings taken with the help of developed instrument. After having consultation with the CMO, we came to know that, there is a 1 to 2% variation between the both methods which is normally admissible. The photograph of the developed instrument is shown in fig.8. In case of any abnormality in the physiological parameters, the system sends message to the doctor's cell phone shown in fig.9. The photo-snap of the experimental set up while it was on clinical trials in the hospital is shown in fig.10. The system has shown its feasibility with GSM network for human physiological parameter monitoring and notification in case of medical emergencies along with fall detection.

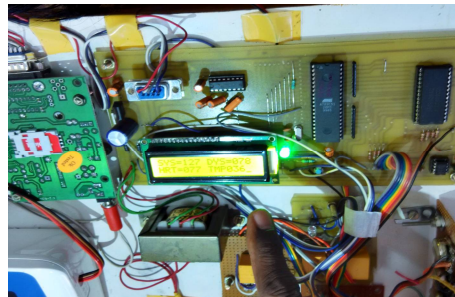


Fig. 8. The experimental setup

The location identification is achieved through GPS. The system gets the geographical locations from GPS receiver to calculate the latitude and longitude of the place/location and prepares a SMS and sends the information through the GSM modem to the mobile phone of the doctors as in fig.9.



Fig. 9. Cell phone with SMS sent by developed system

The details of this SMS are as follows:

- Body Temperature (BT) = 033
- Blood Pressure (Systolic) = 133, (Diastolic) = 082
- Heart beat Rate: 097
- Fall status of the patient: FS = 1 (Fall occurred)
- FS = 0 (No Fall)

The GPS locations are:

- * LAT=1718.8014.N (Latitude North)
- * LON=07652.6666.E (Longitude East)

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Fig. 10. Photograph of the instrument while on clinical trial

From the above discussions it is clear that the system is fully automatic, wireless, portable and practically suitable for patients.

VII. CONCLUSION

The main purpose of this work is to sense, send, display and store the physiological parameter such as human body temperature, heart rate, blood pressure and occurrence of fall at a low cost approach. The system is simple, low cost as it is implemented on 51 Architecture Microcontroller and portable. Care has also been taken to ensure very low power consumption as the device has to be carried by the patient. The reduction of the cost of hospitalization & assistance and to increase patient's quality of life is the aim of this work. This **Personal Health Monitoring & Rapid Response System (PHMRRS)** has functioned satisfactorily and can be used by elderly people or people suffering from variety of medical ailments & thus to improve medical care quality of adult people.

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