Development of a Blood Pressure Monitoring System for Home health Application

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***Abstract*—A wireless physiological parameter monitoring system is presented in this paper for home health application. This system includes real time continuous collection and evaluation of physiological parameters like blood pressure, pulse rate and fall of an elderly at home. A reliable wireless personal area network like bluetooth has been used for this purpose. The hardware design of this system consists of sensors, PIC microcontroller, bluetooth module and mobile phone/laptop. This system provides safe and accurate monitoring. It also gives the freedom of movement.**

***Index Terms*—smart phone, bluetooth module, blood pressure monitoring, fall detection.**

I. INTRODUCTION

Hypertension is one of the leading non-communicable disease (NCD) risk and estimated to be attributable for nearly 10 per cent of all deaths in India [3].The early detection and control of hypertension can reduce the risk of heart failure, heart attack, stroke and kidney failure. Self monitoring of HTN is recommended [5] in order to manage the hypertension in patients across the world. The daily blood pressure monitoring leads to better blood pressure control. Self monitoring and self management of hypertension is particularly important in India because health care delivery is limited by geographic and economic facts.

Biomedical devices benefit from the rapid growth of wireless technology for measuring physiological signals. The use of wireless communications in health care systems provides great mobility and improved comfort level of patients [9]. The wireless technology for biomedical applications should be suitably selected depending on the data rate and range required for the transmission [4].

In this work a wireless BP measurement system is proposed for continuous monitoring of blood pressure values at home environment. A cuff based oscillometric wrist sensor is used in this work for implementation. An embedded platform is used for collecting and analyzing the data from the pressure sensor and transmitting to a personal computer. A fall detection sensor is also attached to the system for identifying the fall of an elderly as discussed in [6,7].

The physical condition of the elderly person is immediately sent through Bluetooth module to the local monitoring station where the central monitoring takes place which can be a laptop or a mobile phone. The data can be sent to the medical practitioner so that frequent visit to the hospital can be avoided for elderly patients. The authenticity of the data is high because the sensors itself send data rather than manually entering the parameter values by a care giver. This paper is organized as follows: Section II describes the wireless technologies for patient monitoring application. The design of physiological parameter monitoring system is discussed briefly in section III followed by results and conclusions in sections IV and V.

II. WIRELESS TECHNOLOGIES FOR PATIENT MONITORING APPLICATIONS

Bluetooth (IEEE 802.15.1) and ZigBee (IEEE 802.15.4) are protocols using small, low-power digital radios or Low-Rate Wireless Personal Area Networks (LR-WPANs), via short-range radio [11,12]. ZigBee working band is di-vided into three frequency bands of 868MHz, 915MHz and 2.4GHz [11].The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. Bluetooth wireless communication module has the advantage of higher data rate and easy interfacing with personal digital assistant such as a smart phone.

III. DESIGN OF BLOOD PRESSURE MONITORING SYSTEM

A. System Architecture

The overall system consists of microcontroller, Blood pressure sensor, Bluetooth module, power supply and Laptop/Personal Computer. A smart phone/laptop based network was used for the purpose of real time analysis of data. The system architecture at the patient end is shown in figure 1.

1) Blood Pressure Sensor: A cuff pressure sensor that can be connected at the wrist of a patient is used in this work. PIC micro controller inflates and deflates the cuff for measuring

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systole and diastole values of the patient using proper algorithms. Systole, Diastole and Pulse rate values are obtained as ASCII values which are converted to integers and processed by the micro controller module. The data were processed and the sent to the COM port of the Laptop/PC. The American Heart Association (AHA) chart shown in Figure 2 is used for categorizing the received data obtained from the pressure sensor. BP sensor is connected at the hardware serial port of the microcontroller.

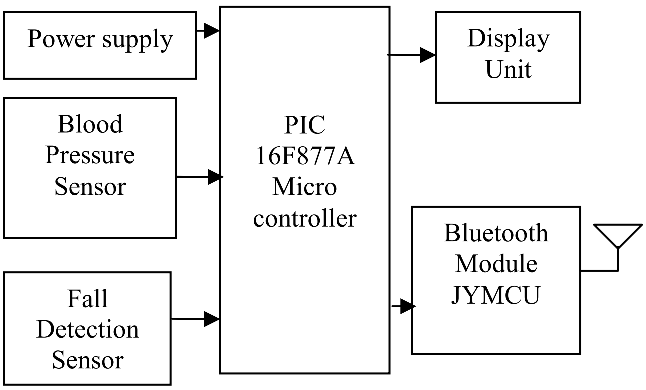

Fig. 1. System architecture at the patient end

Blood Pressure Category	Systolic mm Hg (upper #)		Diastolic mm Hg (lower #)
Normal	less than 120	and	less than 80
Prehypertension	120 – 139	or	80 – 89
High Blood Pressure (Hypertension) Stage 1	140 – 159	or	90 – 99
High Blood Pressure (Hypertension) Stage 2	160 or higher	or	100 or higher
Hypertensive Crisis (Emergency care needed)	Higher than 180	or	Higher than 110

Fig. 2. AHA chart for different stages of Blood Pressure

2)Accelerometer Sensor: MMA 7361L Accelerometer is used in this work as a fall sensor[10]. It provides x, y and z axis values.A wearable sensor system called Smart Wristlet, providing 24 hours fall detection service is discussed in[8]. The system collects data that reflect the wearers activity from multiple channels, i.e., pulse sensor, 3 orientation angles and 3-axis acceleration signals. In this work the fall detection sensor offers a 0g-Detect feature that provides a logic high signal when all three axes are at 0g. This feature enables the application of Linear Freefall protection if the signal is connected to an interrupt pin or a poled I/O pin on the microcontroller.

3)Bluetooth Module: JYMCU HC-05 Bluetooth Module is connected with the microcontroller module for wireless transmission of data. Connection is established by first sending the data at 11520 bps in command mode and then reducing the rate to 9600bps. Bluetooth module is connected at the software serial port of the microcontroller

*4)*Microcontroller Module: The design and implementation of the monitoring system is based on embedded system. Embedded system is a fast growing technology in various fields like industrial automation, home appliances, automobiles, aeronautics etc. Embedded technology is implemented to perform a specified task and the programming is done using embedded C. The PIC 16f877A microcontroller is used at the patient end. This is a high-performance 40 pin microcontroller. It has 8K Program memory, 368 bytes of Flash programmable and 256 bytes of EEPROM. PIC is an extremely efficient microcontroller which runs with typically less program memory than its competitors [13]. The system architecture at the monitoring end is shown in Figure 3.

5) Laptop and a Mobile phone: The Bluetooth dongle connected at the USB port of the laptop allows data to be received by the system. Any software for receiving data from COM port can be used to display the values. TinyBootloader software is used here to display the values.

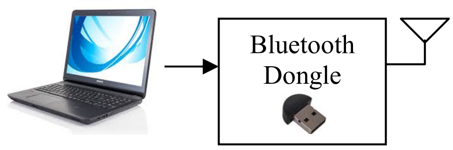

Fig. 3. Receiver end using a laptop

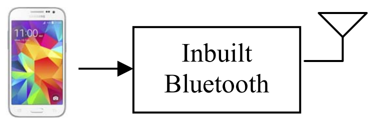

Fig. 4. Receiver end using a mobile phone

Android Studio is used to develop an application in an android smart phone to receive and process the data obtained from the sensors. The application asks to turn on the blue tooth facility. A Motorola Moto-G smart phone is used in this work. After establishing a connection with the transmitter module it stores the received data along with the time. The sensor data were displayed in the smart phone screen by developed android application.

B. Data Flow Diagram

MPLAB IDE is used for writing, compiling and uploading the program into the PIC Microcontroller development board. The data flow diagram is shown in Figure 5.

IV. RESULTS

The systole, diastole and pulse rate values are obtained at RS232 COM port of the laptop. If accelerometer values remains high for a threshold time an alert message is sent to the display system as a person fall. Figure 6 shows the output at the COM port showing the real time sensor readings.

The android application is developed to receive and store the sensor information as well as to send an email to the caregiver with the history of encountered situation. The application will request to turn on the Bluetooth connection. An automatic SMS facility is incorporated to predefined phone numbers in case of emergency situations such as parameters exceeding a threshold value. The various screen shots of mobile applications are shown in figures 7 and 8.

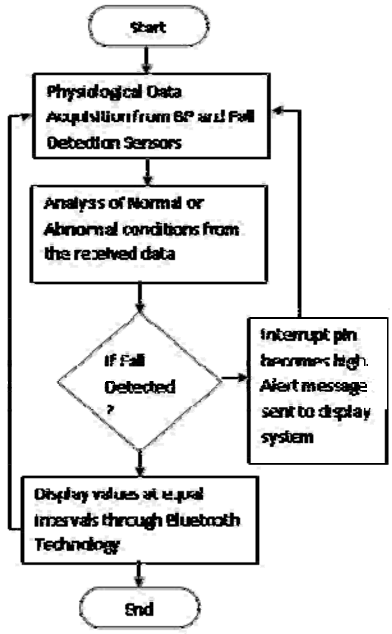

Fig. 5. Algorithm for transmitter section

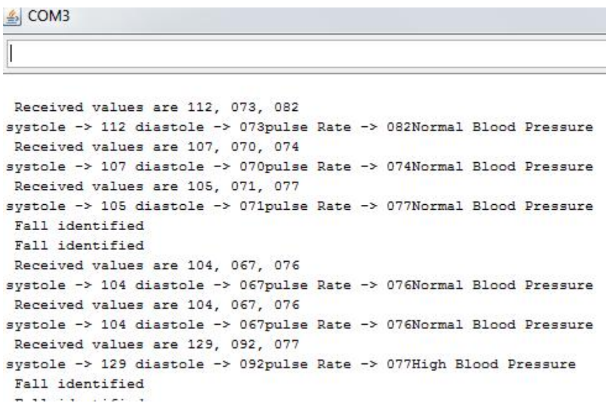

Fig. 6. Sensor values received at Serial port of the laptop

Figure 7 shows the available Bluetooth devices in which HC-05 is shown. After selecting the HC-05 , the module will establish a connection with the sensor network.

Figure 8 shows the sensor data. The sensor data were stored in the data base with time and date of reception. This can be sent to the medical practitioner or caregiver.

V. CONCLUSION

This paper stresses the design and development of home health monitoring system based on Bluetooth technology and smart phone/laptop. The microcontroller collects real time data from the sensors and delivers the signal to a laptop/PC or a smart phone via Bluetooth technology. An android application is developed for acquiring sensor information. The collected information is transmitted to the medical practitioner via e-mail facility with the help of mobile application.

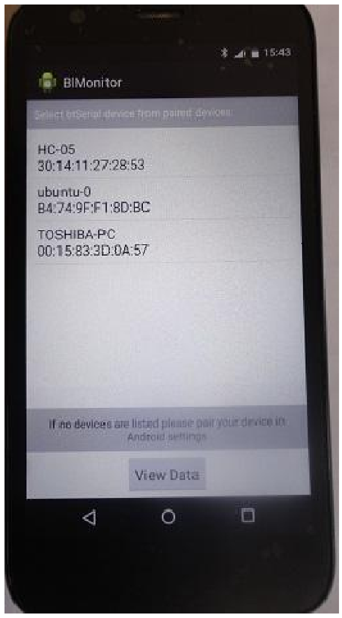

Fig. 7. Mobile application showing Bluetooth devices nearby

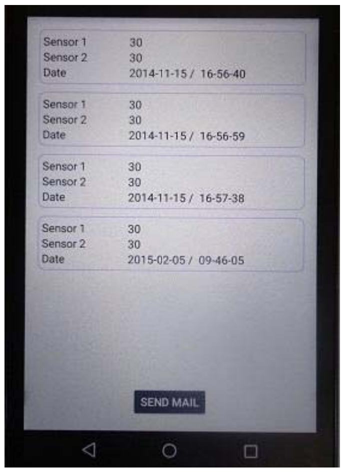

Fig. 8. Mobile application showing sensor values

The monitoring device can be improved by imparting systems for measuring more physiological parameters like glucose level monitoring, ECG, body temperature etc. The information can also be sent as a short service message(SMS)through GSM network to the care taker or the relative in case of emergency situations by incorporating a GSM Module with the embedded system.

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