Embedded Health Monitoring System

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Abstract— This paper proposes the remote monitoring of the health of the particular patient and collects vital parameters of the patient like Heartbeat, Body temperature, Spo2 level, BP and also assists paralyzed patients for their food and water with unique Eyeball Sensor embedded in it. It has been done in an android platform i.e. initially acquisition of sensor data, processing of data and transmitting these data into mobile, which announces the measured data by voice application and also if measured parameters are abnormal, then data can be transmitted to Hospital too. Thus a portable, less time to build and a low cost embedded health monitoring system with extra facility of sensors are very helpful in Health monitoring system

Key words: Sensors, GSM, Android Mobile, Text to voice.

I. INTRODUCTION

Health monitoring system is most important especially in case of older people and critically ill. By 2025, 761million of people in the world will be over 65 years [1]. People with coronary heart diseases are at the top of the world death cause list and every year 7.2 million people die because of these diseases and that too due to lack of health monitoring. The high costs involving the conventional methods and the frequent problems in patient transporting necessitates a different way of providing good medical care. Thus, home care services are becoming rather important in the last few years. Conventional home care basically involves a fixed and limited number of visits by a trained nurse to a patient's home. All activities during these visits are controlled by the nurse: they may include vital signals recording, general assessment of the patient's therapy progress, medication and patient's instruction on particular needs observed during the visit [2]. This concept was not so successful, since nurses have to come from hospital to patient's home and take readings, apart from their works. Alternatively, Telemedicine approach [3] proves to be costly and complex one. Later telemedicine was provided through GSM or Satellite communication [4]. The mobile phone has been recognized as a possible tool for telemedicine since it became commercially available [5].

The use of the Internet by health care providers, and also by their patients, has seen dramatic increases in the past few years [6], [7]. Biosensors included both heart rate, body temperature sensors and BP sensors are added [8], [9]. The ECG and saturation percentage of oxygen (SpO2) module is a new sensing device, developed for the H@H project [10].

In this proposed work, we are introducing Heartbeat, Body temperature, blood pressure, spo2 and Eye blink sensors (for paralysed people) [11] as input to the Renesas microcontroller (64 bit), which has inbuilt 10-bit ADC. At output side, processed data are transferred to android mobile via GSM Network. By installing text to voice application, we can convert text data into voice. Our preliminary results indicate that the system prototype provides relatively correct results.

In this paper we present a more generic, open approach which we believe will lead to more flexible and adaptable personal and telehealth services in future.

II. SYSTEM ARCHITECTURE

The System architecture, fig. 1 shows the block diagram of the Advanced Embedded based health monitoring system. Various physiological biometrics such as body temperature, pulse rate, Spo2 level, and blood pressure are continuously monitored as well as controlled wirelessly using GSM with this system.

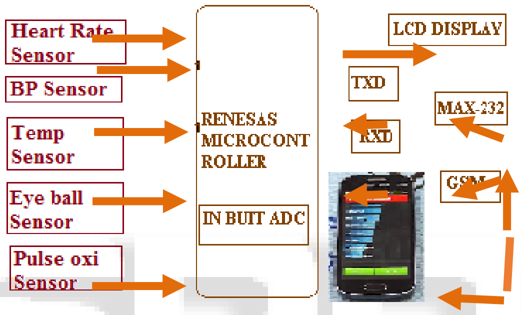

Fig. 1: Architecture of Embedded Based Health Monitoring System

It contains inputs to the microcontroller as Heart rate sensor, BP sensor, Sp02 sensor, Eyeball sensor and Temperature sensor. The Renesas microcontroller has in-built ADC in it. The processed data are sent to Android mobile. The main hardware components are described as follows.

A. Heartbeat Sensor:

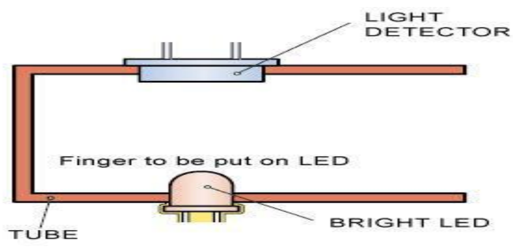

Fig. 2 Heartbeat Sensor

The sensor consists of a bright red LED and light detector shown in fig 2. The LED needs to be super bright as the light must pass through finger and detected at other end. Now, when the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal. The output signal is also indicated on top by a LED which blinks on each heartbeat. This digital output can be connected to microcontroller directly to measure the beats per minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse. It can be used for patient monitoring system and Bio-Feedback control of robotics applications.

B. BP Sensor:

The active sensor in this unit is the SenSym SDX05D4 pressure transducer. The sensor produces an output voltage which varies with the pressure measured in the cuff. It includes special circuitry to minimize errors caused by changes in temperature. We provide an amplifier circuit that conditions the signal from the pressure transducer. With this circuit, the output voltage from the Blood Pressure Sensor will be linear with respect to pressure. Blood pressure is recorded as two numbers—the systolic pressure (as the heart beats) over the diastolic pressure (as the heart relaxes between beats). The measurement is written one above or before the other, with the systolic number on top and the diastolic number on the bottom.

C. Body temperature Sensor:

The third input to the microcontroller is temperature sensor i.e. LM 35 Sensor. Here the three length wires are connected to three terminals of the pins of LM 35. The LM35 series are precision integrated-circuit temperature Sensors whose output voltage is linearly proportional to the Celsius temperature. The sensor circuitry is sealed and not subject to oxidation. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. The output voltage is converted to temperature by a simple conversion factor. Normally the body temperature for a normal adult is about 35 degree Celsius. The general equation used to convert output voltage to temperature is:
Temperature (ºC) = Vout * (100 ºC/V)

So if Vout is 1V, then, Temperature = 100 ºC. The output voltage varies linearly with temperature.

D. Eyeball Sensor:

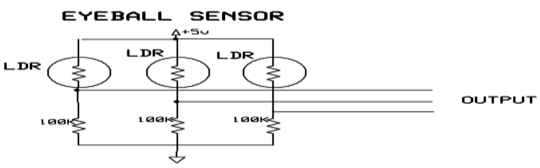

Fig. 3: Eye Ball Sensor

An eyeball sensor in fig.3, LED emits the rays when it is energized. The LDR senses the reflected rays. Object obstructs the rays reflects low rays when it is dark in color and reflect full rays when it is light colored. Depends upon the position of eyeball the LDR value varies. Therefore sensor output varies depends upon the status of eyeball. Here IR led is selected instead of normal LED which will not disturb the driver. If patient's eye ball is moved left, then the coding is done in microcontroller such that the Android mobile produces a voice as "patient needs water", if eye ball is moved right, then mobile produces voice as "patient needs food"[11].

E. Pulse Oximetre Sensor:

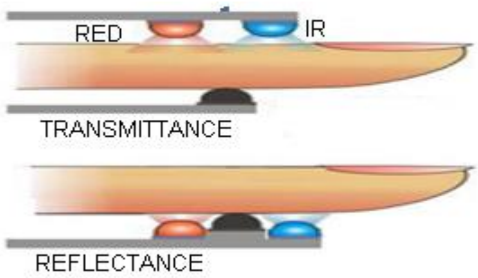

Fig. 4: (a) Transmittance and (b) Reflectance configure rations of transducer

Pulse oximetry has traditionally been done in two methods as shown in fig 4a and 4b: transmittance and reflectance of light. In transmittance pulse oximetry, light is transmitted through the tissue using LED lights and are detected on the other end using a photo detector. In contrast, reflectance pulse oximetry uses a photo detector on the same side as the LED to detect the light reflected by the tissue.

Two wavelengths of light are used shown in fig 5; 660 nanometers (red) and 940 nanometers (near infrared). At 660nm, reduced hemoglobin absorbs about ten times as much light as oxy hemoglobin. At the infrared wavelength, (940nm), the absorption coefficient of oxy hemoglobin is greater than that of reduced hemoglobin as shown in figure 5. The pulse oximetery directly senses the absorption of red and infra-red light and the ratio of pulsatile to non-pulsatile light at the red and infrared wavelengths are translated through complex signal processing to a function of the arterial oxygen saturation.

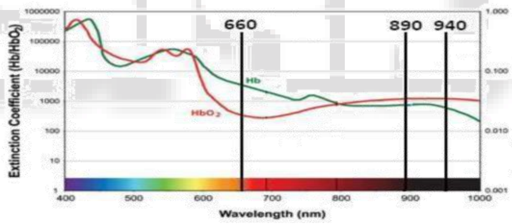

Fig. 5: Light absorption characteristics of HbO2 and Hb at different wavelengths

The pulse oximetery directly senses the absorption of red and infra-red light and the ratio of pulsatile to non-pulsatile light at the red and infrared wavelengths are translated through complex signal processing to a function of the arterial oxygen saturation. Precise measurements of the arterial oxygen saturation can be carried out invasively with co-oximetery. The estimation of Spo2, commonly referred as Spo2, is a function of the measured magnitude at the systolic and diastolic states on the two photo plethysmograms (PPG).

$$R = \frac{(AC_{660})/(DC_{660})}{(AC_{940})/(DC_{940})}$$

This value represents a ratio of reduced to oxygenated haemoglobin. Using this oxygen saturation is calculated based on empirical data.
Spo2=110-25 X R

F. Renesas Microcontroller (64 pin):

Microcontroller Renesas RL 78, which has in built ADC (10 bit precision). It is a large portfolio of low-power, high-performance MCUs with DSP capability, safety features, scalable memory, wired and wireless connectivity, cost-effective, enhanced user interfaces and also general purpose device.

G. LCD Display:

Alpha Numeric displays form an integral part of the Embedded Systems. The Data displayed here is controlled by the Microcontroller. The Control pins like Read Strobe, Read/Write and Enable are controlled through the Microcontroller Ports. The 8 bit data is also provided through a Microcontroller Port. Here the pins, Vss-Gnd, Vdd-Supply, Vo-Input signal, Rs (H/L)-H for Data signal, L for Instruction signal, R/W- Read or write signal, E- Enable, DB0-DB7 are Data pins.

H. GSM Module:

GSM stands for Global System for Mobile Communications formerly called as *Groupe Spécial Mobile.* Here SIM300 GSM Module is used. SIM300 is a Tri-band GSM/GPRS engine from SIMCOM Ltd., SIM300 can fit almost all the space requirement in an application, such as Smart phone, PDA phone and other mobile device. The physical interface between SIM300 and the mobile application is through a 60 pins board-to-board connector, which provides all hardware interfaces from module to customer's boards except the RF antenna interface. The GSM commands embedded in the controller takes care to communicate with the GSM Module via RS232 cable-MAX232-Serial I/O pins of the Controller.

III. SOFTWARE REQUIREMENTS

A. Cube Suite+ Software:

Integrated development environment Cube Suite+ (Cube suite plus) offers the ultimate in simplicity, usability, and security for the repetitive editing, building and debugging that typifies software development. Cube Suite+ bundles all the basic software necessary for MCU software development in one convenient package**,** ready to use immediately after initial installation. Cube Suite+ is also compatible with hardware tools. C Compiler for RL78 and 78K Families is intended for the development of ROM-based systems for embedded applications. In addition to powerful optimization functions that help boost code efficiency and speed up program execution, this package provides extension functionality to support a broad range of embedded devices.

It is programmed for measuring heartbeat, body temperature, & BP. Program for heat beat is written such that patient's thumb is placed for 15 seconds, beats are counted and then beats are multiplied by four to have heart rate in beats per minute. After 15 seconds the buzzer will make sound by confirming that reading has been completed. It is programmed to read temperature if temperature exceeds 40°C, then a alarm message will be sent, showing that as a high temperature. Similarly, codes for BP measurement are written in the main program. Separate codes like GSM test and initialisation codes, System initialisation, user defined functions and device driver implementation codes for ADC, CGC, Ports, Timers, and Serial Modules have been written.

B. Flash Programmer Package:

Flash Programmer is a software package used to program the on-chip flash memory of microcontrollers. It provides usability and functionality optimized specifically for flash programming.

C. Android Software:

Android is a stack of software for mobile devices which includes an Operating System, middleware and some key applications. Using Android enabled mobile, messages are received from GSM Module related to measured Heartbeat, Temperature and BP etc. So we will get measured parameters on mobile display and as well as on LCD display. Now it is the time to have voice output from the Mobile.

D. Text to Voice:

Once the messages come from Microcontroller to android Phone, then it is converted from messages to voice output by installing Android "Text to Voice application" in Mobile.

To implement Heart rate as shown in fig 6, as we previously described that the left thumb finger is to be placed in a small heart measuring device for fifteen seconds, Buzzer is placed to indicate time completion of reading of Heart rate. Heart measuring unit consists of three wires; one for ground, second wire for Vdd (+5V) and third one for analog output wire connected to the microcontroller's input port.

Fig. 6: Heart beat sensor

Body Temperature is measured by connecting three long wires to LM 35 device as shown in fig 7. The LM 35 unit consists of wires, two for supply and an output wire connected to the microcontroller's input port.

Fig. 7: Temperature Sensor LM 35, connected with 3 length wires

BP sensor consists of a Cuff, wrapped around the arm of a patient and by inflating the air from bulb pump, the arm gets tightened and measuring systolic pressure and then afterwards by releasing bulb pump slowly, we can note diastolic pressure.

Spo2 sensor shown in fig 8 has finger clip, by placing our left forefinger in it, we can note down the readings of percentage of oxygen saturation levels as shown in below fig 8.

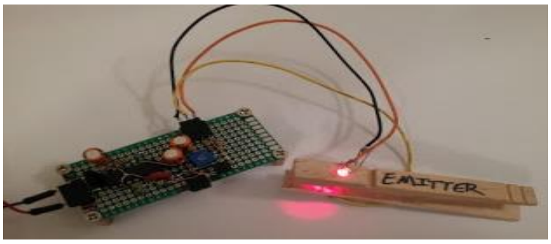

Fig. 8: Spo2 sensor

Microcontroller has inbuilt ADC, converts analog data into digital for processing the digital data and after processing, data will be sent through GSM Module to android phone. The android phone displays the message and converts text to voice output. The complete prototype is as shown in fig 9.

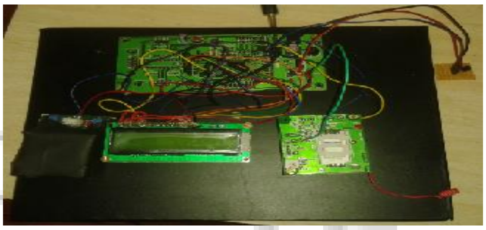

Fig. 9: Snap shot of our built prototype

IV. CONCLUSION

Proposed Embedded Health Monitoring System, which can be easily custom-built for various medical applications and can be used by physicians or non-technical staff. It uses available communication equipment (mobiles) and without extra cost infrastructure using simple non-invasive techniques can increase the health care system performance, reduce time and cost for patient's travelling and helps doctors to quickly diagnose and start treatment. This System is very useful compact and portable, very useful in monitoring accident victims when they are being transported to hospital.

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