Real-Time, Remote, Home Based, Non-invasive, Elder Monitoring System

Rajesh Kannan Megalingam, Vineeth Radhakrishnan, Akhil Kakkanattu Sudhakaran, Deepak Krishnan Melepurath Unnikrishnan, and Denny Chacko Jacob

Amrita Vishwa Vidyapeetham, Amritapuri, Clappana P.O., Kollam-690525, Kerala, India
rajeshm@am.amrita.edu, zarbon001@gmail.com, akhil.ase@gmail.com, mu.deepakkrishnan@gmail.com, dennychakko@yahoo.co.in

Abstract. Real-time monitoring of the physical condition of the elderly people has become mandatory nowadays. The reason for rise in demand of aging services is due to the rise of the elderly population. We need precise, fast and effective transmission of information about their health condition to the concerned. Also there lies a need to transmit more parameters and more data for the convenience and effective response by the concerned people. Since we need an effective response we make use of the voice-call facility apart from the SMS mechanism also. The system proposed here called Noninvasive Elder Monitoring System (NEMS) monitors blood pressure, heart rate, temperature and ECG of the elders. Any critical condition is reported to the medical service center and relatives via an SMS and voice call, to arrange for proper services to the elder at right time. We make use of the GSM modem for the SMS and voice call facility.

Keywords: Voice call, ECG, Heart rate, GSM modem, SMS.

1 Introduction

This fast moving world, where people are in a rat race to make their both ends meet, a very important section of the society which is our elder population has been ignored quite easily. This is a very critical social situation and should be tackled as soon as possible. As the life expectancy of the population in many countries is increasing the elder population is also increasing which increases the responsibility of the young generation to care for these elders. Traditionally elder care has been the responsibility of family members and was provided within the extended family home. Increasingly in modern societies, elder care is now being provided by state or charitable institutions. The reasons for this change include decreasing family size, the greater life expectancy of elderly people, the geographical dispersion of families, and the tendency for women to be educated and work outside the home. Although these changes have affected European and North American countries first, it is now increasing.

Most elders would prefer to continue to live in their own homes. Unfortunately, majority of elderly people gradually lose functioning ability and require either additional assistance in the home or a move to an eldercare facility. The adult children of these elders often face a difficult challenge in helping their parents make the right

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choices. Usually many bed ridden elders are taken to the hospitals and they spend rest of their life in a hospital bed.

It is this situation which led us to propose an architecture by which old people can be in their home with sensors attached to their body non-invasively. The system is called NEMS – Noninvasive Elder Monitoring System. The vital parameters are monitored continuously and processed by NEMS locally in a computer at their homes. The computer processes the parameter to find critical conditions and report the same to the medical services for timely help. The relatives of the elders are also informed via SMS and voice call facility using GSM modem.

2 Related Work

The ECG monitoring system in [1] only deals with the heart beat monitoring using ECG, which only gives limited information about the present condition of the patient. This system is very costly compared to the system we are proposing here. Paper [2] also deals with the monitoring of heart beat, it does not use any other sensors for monitoring other biological parameters like blood pressure and temperature and it does not make a voice call to the concerned authorities and relatives. Voice call is very important as it can be seen that there are lot of chance that an SMS goes unnoticed, especially during night times. Our system specifically does a voice call along with the SMS messaging. [3] Gives importance to the changes of behavior of patient sensed via camera and force sensors. It does not deal with measuring temperature or heart rate, which are important parameters that should be taken care of especially for elderly people. In [11] authors have proposed the wearable jacket for patients to monitor ECG which might be very uncomfortable for bed ridden elders. Also it is more applicable only for cardiac patients. NEMS uses a wearable glove which is comfortable for elders.

3 Methods and Methodologies

The home based NEMS as shown in Fig.1 consists of the Pair of Gloves, Sensors, Intelligent Wireless Controller (IWC), Receiver and PC module, SMS and Voice Call Gateway (SVCG).

3.1 Pair of Gloves

These are the gloves that the bed ridden elders wear for the vital parameter monitoring. They have the sensors as described in B in this section. The sensors are integrated with the Intelligent Wireless Controller as explained later in this section**.**

3.2 Sensors

The Sensor Microcontroller module consists of four different sensors for measuring the following four parameters: *Heart rate, Blood pressure*, *ECG*, *Body temperature.*

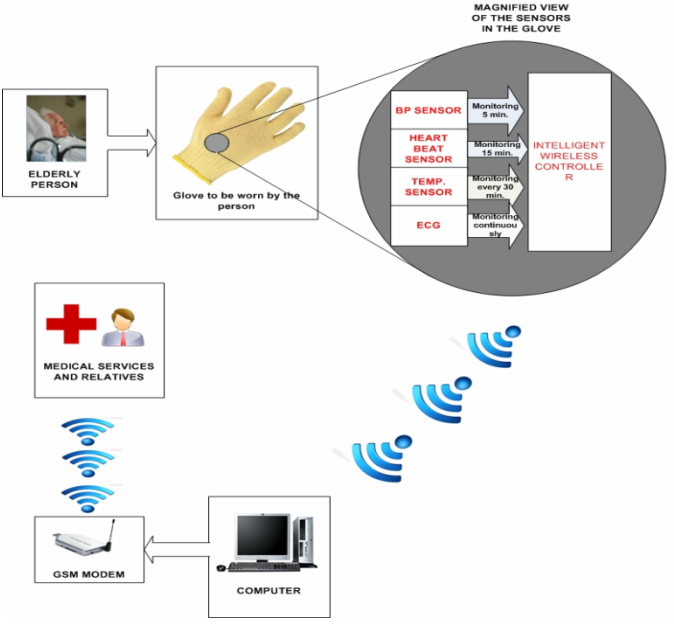

Fig. 1. NEMS Architecture

3.2.1 Heart Rate

Heart rate is the number of heartbeats recorded per minute typically recorded as Beats per Minute (BPM) as in [7]. In the proposed system, we make use of a technique called Photo-plethysmography (PPG). PPG is a simple and low cost optical technique that can be used to detect the blood volume changes in the micro vascular bed of tissues. In this technique, a bright led and a LDR is employed to detect the blood flow at the finger tip or any other peripheral part of the body. The light from the bright led gets reflected from the tissues in the body parts and the amount of light reflected determines the volume of blood flowing. If more blood flows through it, more light is reflected back.

We have to amplify the signal and remove unwanted noise signals. For this purpose we make use of operational amplifiers, LM358. The circuit is shown Fig. 2.

We get the output in the form of analog voltage signal and its peak value is around 3V. We feed this data to IWC.

3.2.2 Blood Pressure

High blood pressure is a common risk factor for heart attacks, strokes and aneurysms, so diagnosing and monitoring it are critically important. However, getting reliable blood pressure readings is not always easy. Traditional blood pressure monitoring requires a cuff, wrapped around the upper arm and inflated until blood flow is completely cut off. The examiner then gradually releases the pressure, listening to the flow until the pulse can be detected.

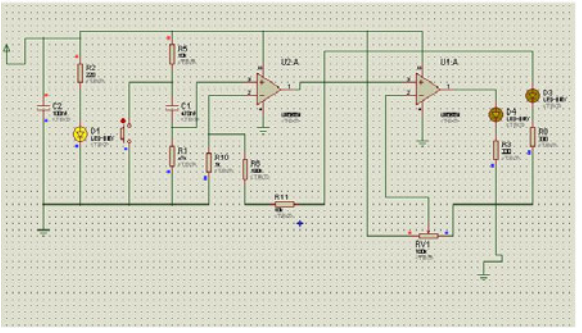

Fig. 2. Noise Filtering Circuit

With the new monitor as in [4], no cuff is required. Instead, the device takes advantage of a method called pulse wave velocity, which allows blood pressure to be calculated by measuring the pulse at two points along an artery. The two points decided are two points of index figure. That posed a challenge because blood pressure in the hand varies depending on its position: If the arm is raised above the heart, the pressure will be higher than if it is below the heart. The researchers solved that dilemma by incorporating a sensor that measures acceleration in three dimensions, allowing the hand position to be calculated at any time. This not only compensates for the error due to height changes, but also allows them to calibrate the sensor for more accurate calculation of blood pressure. As the wearer raise the hands up and down, the hydrostatic pressure changes at the sensor. Correlating the change of pulse wave velocity to the hydrostatic pressure change, the system can automatically calibrate its measurement. The equivalent analog output signal will be fed to IWC.

3.2.3 ECG

An ECG sensor is important for patient monitoring system because their analysis give clear information about cardiac regulation and well insight about pathological conditions. Also, the system should be user friendly, simple, reliable and of affordable cost. The two electrodes of the ECG sensor are connected to the body as in [5] and the signals collected are amplified by means of op-amps (LM358N) so as to interface it with the IWC. The gain of the op-amp is controlled by varying the resistors attached to it. The circuit is shown in Fig. 3.

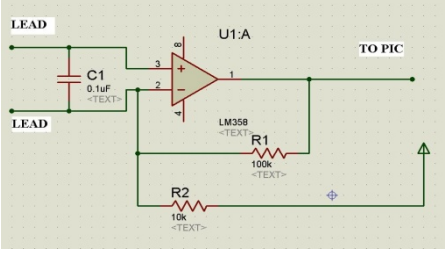

Fig. 3. ECG Sensor Circuit

Here we are using two op-amps so as to reduce the effect of noise generated while sensing.

3.2.4 Temperature

The LM335 series are precision, easily-calibrated, integrated circuit temperature sensors. They are two terminal devices like a Zener and have a break down voltage directly proportional to the absolute temperature at +10mv/°K. The LM335 operates in the range of -40°C to +100°C as given in [6]. LM335Z can measure temperature ranging from -40°C to +100°C. The output from the temperature sensor is an analog signal and is fed into IWC.

3.3 Intelligent Wireless Controller

This consists of a microcontroller to process the analog signals and wireless interface to transmit the processed signals to the PC. The microcontroller and the wireless interface should be a simple and powerful one such that the gloves don't become too heavy for the elders. One option for the wireless interface is to use simple RF TWS 434 Receiver and Transmitter modules. These are light weight and can be easily integrated with microcontrollers. Another option is to use Zigbee transmitters and receivers.

3.4 Receiver and PC Module

The digital data from the IWC is sent to the PC from the wireless receiver module TWS 434, using RS232 cable. The output from the receiver is send to the level shifter MAX232 and interfaced to the PC via RS232 cable as given in [8]. The customized software installed in PC will process the parameters which are measured in the specific intervals as indicated in Fig.1. These timing intervals are based on the enquiry with a local physician. When the parameters exceed critical value in any case of temperature, heart rate, ECG or pressure, the SVCG is activated to SMS and place a voice call to the medical service center and relatives.

3.5 SMS and Voice Call Gateway (SVCG)

A GSM (Global System for Mobile Communication) modem is used to alert the medical service center and the relatives when there is a abrupt change in the measured parameters which exceeds the critical value.

4 Elder Monitor Algorithm (EMA)

The EMA as shown in Fig.4 monitors the elder's heart beat, ECG, blood pressure and body temperature. All the sensors are made compact and integrated into a small unit which could be fit into a glove. It is so convenient for the elderly that they have to wear the gloves in their hands. The sensors monitor the parameters and if it bounces above a critical value it activates the alert mechanism. To avoid the muddling up of the four sensor outputs, we accept the value from each sensor only after a specified amount of time. We send the data of the body temperature in a time interval of 30 minutes; heart beat every 15 minutes and blood pressure every 5 minutes. Since the

ECG being the most crucial one we monitor and send the ECG value continuously. The parameter values from the sensors are given to the intelligent wireless controller and are sent to the computer. All the parameter values are continuously monitored by a custom software and if a critical situation is encountered the computer instructs the GSM modem to send a SMS and a voice call is made to the relatives and medical service center.

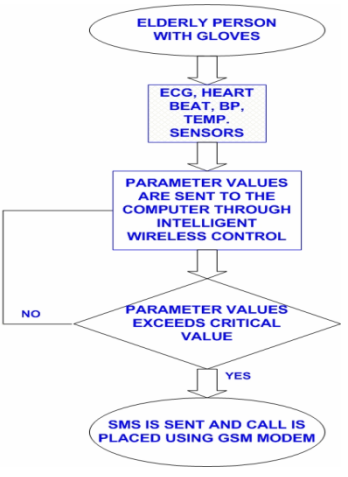

Fig. 4. EMA Flow Chart

5 Modem Control via HyperTerminal

As of now we have conducted simple simulation of sensor circuits. As a preliminary work some simple hardware circuits are also built and tested. Majority of the work is done with the SVCG in successfully messaging and placing a call. The modem which we are using is GPRS/GSM modem. GSM/GPRS modem can be used to send messages and also make a call through computer. HyperTerminal can be used to control the modem. For interfacing HyperTerminal with modem we use the AT commands.

5.1 Setting Up GSM Modem

GSM/GPRS modem is connected to the computer using a RS-232 cable.It is connected to the serial portof the computer. The GSM modem will map itself as a COM serial port in the computer as in [10].

5.2 HyperTerminal Configuration

On the Windows Start menu, Run dialog box is selected. ‘hypertrm.exe’ is typed in the Open field to open the Connection Description screen as shown in Fig. 5. On the Connection Description screen, for Name, "Cisco" is typed and an icon is selected for the definition. The primary COM port is selected for the Connect in the Connect To dialog box. In the COM Properties dialog box, the following selections are made as shown in the Fig. 6.

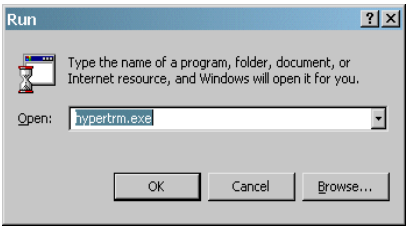

Fig. 5. The Windows Run Dialog Box

Fig. 6. HyperTerminal COM n Properties Dialog Box

Initial setting up of GPRS/GSM Modem, sending SMS through AT commands, and for making call using AT commands we can make use of the reference [9].

6 Conclusion

The system proposed above is simple and cheap that can be used for this purpose. One other beneficiary of NEMS is the doctors who can monitor the physical and medical conditions of the elders from any part of the world and thus can attend to them remotely. Apart from simple circuit evaluations in the preliminary work we have done so far, we are successfully able to SMS and place a call using the SVCG. Obviously the other set of people are the old people who can be monitored from any place with this proposed system.

7 Future Work

Future work involves integrating the entire system as NEMS. The gloves, especially the design and the materials used to make the gloves are yet to be identified and tested. The data can also be stored and used by the doctors to conduct a study and make conclusions. The doctors would be able to give clear and best instructions within the least time. This system can also be used in villages of developing and under-developed countries for remote patient monitoring where there is heavy shortage of doctors.

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