An Intelligent Wearable e-Belt for Continuous Monitoring of Sinus Rhythm

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Abstract

In this paper, we propose a GSM based non-invasive wearable physiological parameters monitoring system. The system can be used to monitor parameters such as temperature and heart rate of a human subject. This system is worn on the waist by an at-risk person. The person is monitored using several sensors and data is sent wirelessly. The device detects if a person is medically distressed and sends message to the hospital, ambulance and relatives. An alarm is set, which helps the user to alert the people around. This intelligent e-belt is helpful for physically challenged and elderly people and also reliable and accurate.

Keywords: *physiological parameters, body temperature measurement, sensors, heart rate measurement, GSM module, Zigbee, GPS module.*

1. Introduction

The proposed work describes the design of a simple, intelligent, low cost micro controller based heartbeat monitoring system integrated with GPS and GSM technology [2][6] which sends alert information at the time of heart attack. The National Heart, Lungs and Blood Institute states that "more than 3million people in India have a heart attack and about half of them die in each year. About one-half of those who die do so within 1 hour of the start of symptoms and before reaching the hospital". A heart attack happens to a person when the blood flow and oxygen supply to heart muscle is blocked and it is mostly caused by the Coronary Artery Disease (CAD).CAD occurs when the arteries that supply blood to the heart muscle (coronary arteries) become hardened and narrowed .It often causes irregular heart beat or rhythm by blocking blood stream .The National Heart, Lung, and Blood Institute suggest that "everyone should know the warning signs of a heart attack and how to get emergency help". With the help of the proposed system we can locate the patient when the patient has heart attack.

In the case of any medical emergency for elderly or physically challenged people suffering from heart diseases, continuous monitoring of the patient is unavoidable. The proposed system is useful to measure the temperature and heart rate of the person and the measured parameters are transmitted to the hospital under any emergency conditions. It also informs the relatives and ambulance driver and locates the patient using GPS and GSM technology.

2. Overview of the existing system

The existing one is a ZigBee based monitoring system [1]. Fig.1 shows the block diagram of the existing system. This system consists of three sensors. The temperature sensor, heartbeat sensor and fall detection sensor. Using these sensors and associated components, the patient is continuously being monitored. The outputs from the sensors are processed by the micro controller unit. The results are sending through the XBee Module [3] to the host computer, which stores the data. If the person is at any emergency condition, an alarm is generated. Once the user is connected to the receiver, the data is automatically updated.
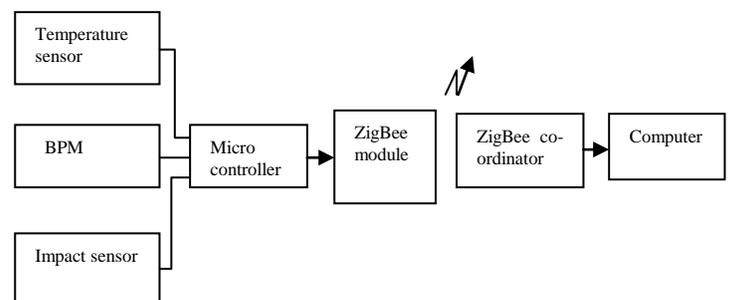

Fig.1. Block diagram of existing system

The temperature sensor measures the skin temperature and the existing system uses DS600 temperature sensor [1]. The temperature sensor circuitry gives an analog voltage corresponding to the measured temperature. This temperature is given to a 12 bit Analog-to-Digital

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convertor (ADC) and is processed by the micro controller C8051F020. The relative changes are monitored within set threshold which sets off the alarm.

A heart rate sensor is designed to measure beats per minute. The heart rate measure is based on near-infrared spectroscopy (NIR). It involves light of wavelength 700 to 900 nm to measure blood volume. No other tissue other than haemoglobin absorbs this light. The amount of absorbed light changes with the flow of blood which is linked to the heart rate. Heart rate sensor consists of an IR LED transmitter phototransistor, and filter circuit. The light detected by the phototransistor is amplified, filtered and send to the micro controller.

An impact sensor is used to detect falls. The existing system uses an ADXL213 accelerometer as an impact sensor. It provides a voltage whose amplitude is directly proportional to the acceleration.

The communication between the micro controller and the receiver unit has been carried out wirelessly by 2.4GHz ISM ZigBee modules.

GSM modems have increased range of operations than Zigbee modules. Through GSM modems messages are send to the doctor, ambulance driver and the relatives under any medical emergency conditions. Using GPS modems location of the patient can be monitored. A 16 series PIC micro controller used in the proposed system is more advantageous than C8051F020.

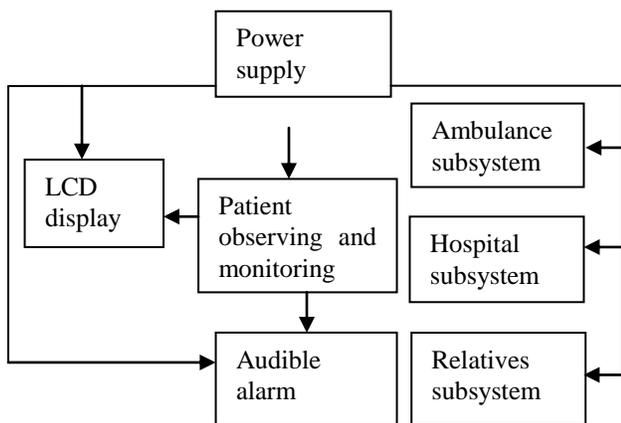## 3. Block Diagram of the Proposed System

Fig 2 Block diagram of the entire system

Figure 2 shows the block diagram of the entire proposed system. The patient observing and monitoring system includes the sensors and the micro controller which are used for patient monitoring. The system consists of subsystems such as ambulance, hospital and relatives to which alert messages are sent if any medical distress happens to the patient. The outputs from the sensors are processed by the patient monitoring system and the results are sent wirelessly to the corresponding subsystems using GSM and GPS systems.

main subsystem
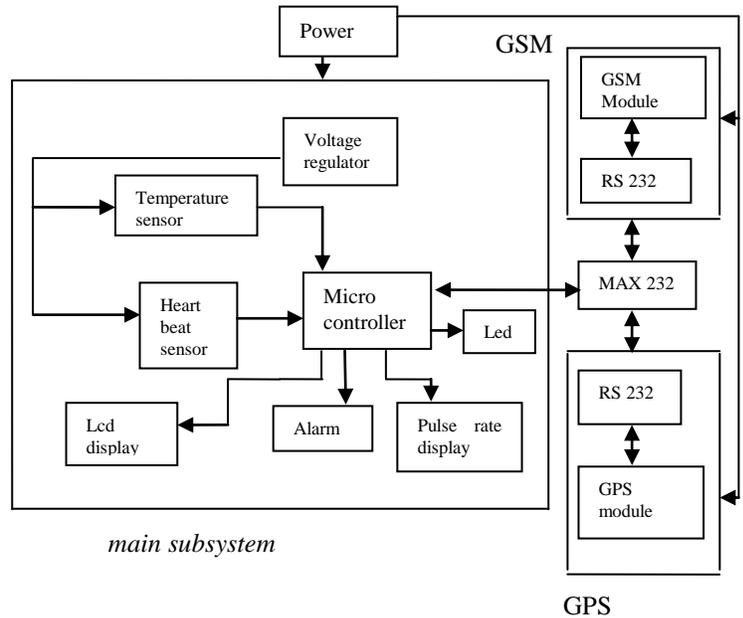
Fig. 3 Block diagram of the patient monitoring system

The system mainly consists of temperature sensor, heart beat sensor, micro controller, GPS and GSM module.
Fig.3 shows the block diagram of the proposed system. The details of the proposed system are depicted as follows.

4. Sensing System

The system consists of two types of sensors, temperature sensor and a heart rate sensor. Temperature sensor is used to measure the temperature while heart rate sensor is used to measure the pulse rate. The outputs of the sensors are given to the micro controller.

The temperature sensor [2] is used to measure the body temperature. The change in resistance is sensed by the sensor. Since change is reproducible, the temperature sensors are very accurate.

In the proposed system, we used LM35 temperature sensor for temperature measurement. LM35 is an integrated circuit sensor that can be used to measure temperature with an electric output proportional to the temperature in degree Celsius. It is connected to the PIC micro controller. The changes in the body temperature indicate that the patient is suffering from any of the following conditions: trauma, heart attack, burns, stroke, and heat exhaustion. The advantages of using LM35 are, we can measure the temperature more accurately than using a thermistor. The sensor circuitry is sealed and not subject to any oxidation. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. The LM35 does not requires any external calibration or trimming and maintains an accuracy of +/- $0.4\degree$C at room temperature and +/-$0.8\degree$C over a range of $0\degree$C to +$100\degree$C.This sensor works under low power dc input of 5V.

A person's heart beat is the sound of the valves in his/her's heart contracting or expanding as they force blood from one region to another. Heart beat rate is the number of times the heart beats per minute. Its unit is BPM. Heart beat can be measured based on optical power variation as the light is scattered or absorbed during its path through the blood as the heart beat changes.

The basic heart beat sensor [2] consists of an LED and LDR which is placed parallel to each other. The finger is placed in between the LED and LDR. The heart beat pulses causes the variation in flow of blood. LED emits IR rays which travels through the finger are detected by the LDR. LDR works on the principle that when light falls on it, its resistance changes. As the light intensity increases, the resistance decreases. Thus the voltage drop across the resistor decreases. The detector output is in the form of electric signals and is proportional to the heart beat. When the heart beat detector is working, the beat LED flashes in unison with each heart beat. This digital output is connected to the micro controller and is processed.

5. Micro Controller

The micro controller used in this project is PIC16F876A. It is a 28 pin PIC with 3 I/O ports. It has got an inbuilt five channel 10 bit ADC module. It has 368 bytes RAM.

The advantages of using PIC micro controller are it has RISC design. It has only thirty five instruction set to remember. Its code is extremely efficient, allowing the PIC to run with typically less program memory than its larger competitors. Also PIC micro controllers are more advanced than other micro controllers. It is low cost, high clock speed.

6. GSM and GPS Modem

GSM stands for Global System for Mobile Communication. GSM modem has a slot for inserting SIM. GSM networks contain Mobile Stations, Base station sub system and network sub system. The mobile station contains IMEI number and SIM has IMSI number. Base station subsystem contains Base Transceiver Station which has antennas for communication. Network subsystem contains Visitor Location Register (VLR), Home Location Register (HLR), Authentication Center (AuC) and Equipment Identity Register (EIR). Mobile Switching Center (MSC) plays a key role for communication between mobile station and PSTN. HLR stores the information about the subscriber and the current location of the subscriber. VLR provides service to the subscribers of HLR who are visitor users. AuC gives the security of the user and to identify the location of the subscriber. EIR is also for security purpose and to identify the mobile station. MAX 232 which is inbuilt in the modem is useful for serial data transmission.

GPS stands for Global Positioning System. GPS is a means for locating any point on earth. GPS is a network of satellite orbiting the earth and continuously transmitting the information. It allows the users to determine their location on land, sea, and in the air around the earth. GPS system does this using satellite and receivers. The satellite senses the information to receivers and the information contains the time, position and satellite strength. The receivers pick up this information and use it to determine the location of the user.

7. Monitoring System

In the proposed system, a 16x2 LCD is used to display the measured value. It is a 16 pin LCD with 8 data lines to transmit the data from the micro controller to LCD. The system consists of a power on LED and status LED. Status LEDs are used to indicate the status of a human subject. Under normal condition green LED blinks whereas any medical emergency occurs the red LED blinks. An audible alarm to aware the people around is also provided in the system which sets if any medical distress happens to the patient.

8. Hardware Implementation

Fig.4 prototype-snap shot

The figure 4 above shows the prototype of the proposed system. LM35 temperature sensor and heart rate sensor senses the temperature and the heart rate of a patient. The PIC micro controller was programmed in Mikro C. In the code, a threshold value for temperature and heart rate is set. The temperature is monitored continuously and the heart rate is checked in every 10 seconds. For heart beat sensor, pulses for 10 seconds are measured and it is multiplied by 6 to obtain beats per minute. Normally the pulse rate is 72 bpm and if any imbalance occurs to either temperature or heart rate, an alarm is generated and message is sent using GSM modem. In this system GSM is used to send message to the hospital, ambulance driver and the relatives to make aware that a patient is medically distressed and an immediate medical assistance is needed. GPS system is used to locate the patient. The latitude and longitude regarding the location of the patient is also mentioned in the message. It helps the ambulance driver to reach the exact place and to take the patient to the hospital. The measured values are displayed through 16×2 LCD. The system also contains two led one red and green to indicate the status of the patient. The entire system works on a regulated 5v dc supply except for gps and gsm modems.

9. Applications and Advantages

New technologies and progress in science offers speed, materials at low cost, miniaturization which results in the development of high performance sensing system. Continues monitoring of people is required especially for people above 65 years of age. With this system patients are continuously monitored using a network of wireless sensors. The cost of hospitalization and rehabilitation after a major surgery is ever increasing. Hospitals itself are looking forward to send people back home as soon as possible. During this recovery period, several parameters like heart rate must be monitored. For that a wearable system like an intelligent belt is necessary to provide immediate medical assistance under any medical emergency situations.

The system is also used for physically challenged people whose temperature and heart rate has to be monitored. If any abnormality occurs message is send to the doctor, relatives and the ambulance driver. Thus ensure medical assistance.

The advantages of wearable smart intelligent e-belt are, it is reliable, non-invasive, comfortable, accurate, low cost and flexible. The belt is worn under the dress so that it is not exposed. The alarm in the circuit alerts the surrounding people that the person needs an immediate medical help. So that first aid can be provided accordingly.

10. Results and Discussions

Fig.5 proteus simulation snapshot

The above figure 5 shows the proteus simulation snapshot of the proposed system. The system is simulated in proteus8 real time simulator and the results were observed. The outputs from the sensors were received and are processed by the micro controller. The LCD, displays the

measured values. Fig 6 shows body temperature and heart beat of a human subject.

The micro controller checks whether there is any abnormality in the measured values. If there are any such problems, an immediate message is sent to relatives, hospital, ambulance driver with location of the patient, thus providing medical assistance.
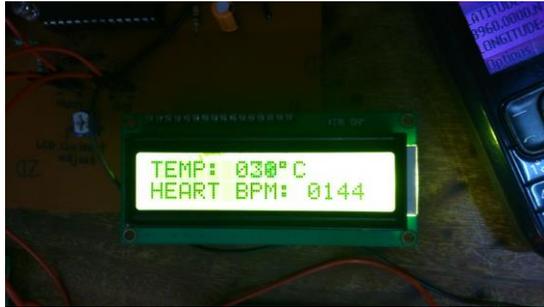

Fig6 LCD display

Conclusions and Future Developments

The addition of a blood oxygen sensor allows to measure the amount of oxygen in blood. Thus the medical distress caused by the reduction of oxygen can be detected. Zigbee modules of high range (7km) are available in the market today [5]. Using these modules transmission of data is possible efficiently and economically. Satellite Communication using M10 [4] satellites is another development. M10 satellites are used as a device for transferring information. The data from the micro controllers are transmitted using M10 modem. The whole health monitoring system which we have proposed can be integrated into a small compact size like a cell phone or watch so that the patient can carry it easily.

The proposed system is used to monitor different physiological parameters such as temperature and heart rate of a human subject. The system consists of sensors, micro controller, GSM system, GPS system. Using several sensors to measure different vital signs, the person is wirelessly monitored. It detects if a person is medically distressed and sends message to the hospital, relatives and the ambulance driver. Auto alarm system is provided which sounds only when the reading exceeds or reduces than the normal level. The proposed system consists of a belt and a finger circuitry. The system is battery powered and less expensive. Continuous monitoring of people can be done effectively by using GSM and GPS modems.

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