Wearable Non-invasive Health Monitoring Device for Elderly using IOT

B Sumathy1*, S Kavimullai1, S Shushmithaa1, S Sai Anusha1

1Instrumentation and Control Engineering Department, Sri Sairam Engineering College, Chennai – 600044.

E-mail: bsumathy.ice@sairam.edu.in

Abstract. Patients and old age people suffering from Chronic, systemic diseases like heart diseases, asthma diseases, Alzheimer and dementia, Kidney diseases etc. needs regular health monitoring and extra care during any emergency. During the world of pandemic, those people suffered a lot and needed more attention from expert/ specialists. Due to the difficulty in consulting the expert specialists in person, wearable technology plays an important role, which evolved for ease of use and advancements for monitoring patient’s health status. So, a wearable health monitoring system using IOT is proposed to monitor the regular health parameters periodically. The proposed system is a single integrated device consists of sensors for measuring vital physical parameters like pulse rate, respiratory rate, and temperature. Those data and initial predictions are sent via IOT cloud platform and expert opinions are received for further action as remote monitoring. If any critical changes are found, the same has been transmitted to doctor end and closest people of contact. If temperature changes are found below or above the standard value about 97 to 99 F, along with any respiratory difficulties with abnormal values are brought immediately to the notice of the specialist, due to the recent treats in covid. The sensor values are monitored time to time and connected to Arduino with GSM module for alert message. The proposed patient health monitoring system based on IOT helps the doctors and family members to keep track of the patient’s health. The covid pandemic period also made us realize to monitor even normal healthy person, which is the need of the hour. Also, the unit is wearable, small in the form of belt/collar, light weight and cheap. The aim of the study is fulfilled, to prognosticate the possibility of unidentified or untreated health effects and monitor the patient health.

Keywords: IOT, HealthCare, Heartbeat sensor, Temperature sensor, Respiratory sensor.

1. Introduction
We live in a world where technology plays a vital role in monitoring human health with an easily accessible wearable technology. This is possible using IOT technology. IOT is the platform which connects various devices, transfer data with a wireless network without human interaction and it is embedded with sensors, actuators etc. Health is the crucial need for the body [1,2]. One of the important factors for superior life is health [1]. Many of us especially oldest people are failed to be monitored and to maintain their health regularly. Thus, there is a non-existence of good medical maintenance between patients, which leads to systemic diseases like heart diseases, attacks, and death rates in old age patients. Also, during the pandemic situation, it is necessary to monitor body
temperature continuously which help in reduces the spread of covid-19 like viruses and helps to protect all from diseases.

In traditional methods, hospitals and doctors play a major role in health monitoring [5]. But it requires a lot of time for early booking, appointment, waiting for the doctor’s consultation and checkup [5]. Regular visits to the hospital are mandatory even for minor problems. By using the latest technology efficiently, this kind of scenarios could be avoided. IoT enables the doctors and healthcare experts to be more connected with the patients and helps in monitoring them regularly from a distant. The main motive of patient health monitoring is to give alert well in advance or critical worsening and it can be achieved by the proposed system.

So, a “Wearable Non-invasive Health Monitoring Device for Elderly using IOT”, is proposed to monitor the health status of patients regularly. The system is a single integrated device consists of sensors to monitor the health periodically. Also, the system is proposed where the permitted personal can ingress these data stored using any kind of IOT based platform and based on these rates received, the diseases are identified by the doctors and experts from a distance. Patients are suffering from heart diseases, asthma diseases, Alzheimer and dementia, kidney diseases etc. needs more care, regular checkups and need more consultation from expert/specialists. This health monitoring system is in the form of belt/collar and it monitors the heart rate (pulse rate), temperature and respiratory rate regularly, if any critical changes is been monitored, it directly informs to the doctor and other closest people of the patient. The proposed system is useful for many patients especially during covid-19 period, patients in quarantine ward for emergency needs. Also, this proposed system would meet the demands of proper health monitoring system and SAVE LIVES.

The flow of the paper is mentioned below. Introduction is the first part, followed by literature survey explaining various patient monitoring systems and devices. Part 3 explained about the method adapted that has included the parts, requirements, and specifications. Discussion of the results obtained in narrated in the next part, followed by conclusion and future works.

2. Literature Survey
In [1], the authors proposed the health monitoring customized system where the system monitors the heart rate in terms of number of pulses and temperature of the persons along with some environmental parameters like gas level in the room via sensors. The data is transmitted through wireless networks which makes an alert to the attendees and healthcare expert, by maintaining a single database of patients, apart from personalization of critical health related criteria. The authenticated medical expert collects the data, analyze and take decisions virtually using the data, without meeting in person. Deepak et. al, [2] proposed a monitoring system using ARM controller and GPRS modem. The system is associated with three sensors which are temperature, pulse rate. These sensor data which are attached to the patient body is sent to the ARM7 controller, and the data is transmitted with the help of Bluetooth module to Smart phone application and cloud with the help of GPRS module. In [3], the authors presented a healthcare monitoring system by IOT platform by utilising My Signals with wireless network system LoRa (Low power long range). Electrocardiogram signals, heartbeat pulse signals, SPO2 level signals, and temperature signals are measured and integrated with LoRa and My Signals. The performance and sensor effectiveness are checked, and analyzed. The vital parameters data are analyzed both by analytical and statistical methods.

In [4], an IOT based health supervisory system is proposed and the data are transmitted via cloud platform. The above device is made as a wearable device and is shortly called as WISE. The authors captured the real time data from the patients using the vital bio signal sensors. The device is made as an integrated device which measures the pulse rate, BP and temperature etc. In [5], a system is developed that measures the heart rate and body temperature using the LM35 and pulse sensor, respectively. These sensors are integrated to the uno board for the control of signals and channelling via wireless networks. In paper [6], the authors proposed a design for the finding pulse rate and functioning of heart. The device is basically a warning kind of prototype and if the values of parameter is beyond the limitation, divergent values of output of Arduino Uno goes to alerting system and further action takes.
place. The proposed design has features like reliable, easy assessable and robust. In [7], the authors aimed to develop the sensor-based healthcare observation and analysing system, without mesh of wiring systems which collects the real time data of bio signals of the patient under investigation. The various parts used are sensors for acquisition of bio signals, signal conditioning units, controlling parts and relevant application software programmed using JAVA. Heartbeat rate, and other vital physiological information is been continuously checked, and further given as output for doctor’s decision. Also, the data are stored for future reference and save life on time.

In [8], the authors reviewed the various latest technologies in wearable biosensors which allows health care providers to predetermine and decide the patient’s vital bio signals traits after the treatments or therapeutics. The challenges faced by healthcare professional are reviewed. In [9], the authors proposed a model for basic health observation unit which is not connected with wire. This model sends the short communication message to the attendee and medical expert. The authors divided the prototype into different divisions as data processing, signal acquisition, and the last division is transmission, receiving divisions. Graphical User Interface is devised for all basic information in the first division. The basic data is entered and checked for vital good signs and there is any deviation in optimum parameters, the same is transferred for further guidance to medical expert. In [10], Prakash Patilet. Et. al, proposed a device which could continuously observe the biological body signals. The observed signals are compared with the optimum or threshold values of signal. When there is much difference between the two, alerting system comes into effort. The warning signal is sent wireless to healthcare personal and neighbours of close contact. In [11], an innovative patient health-care monitoring system is proposed which integrates the wearable devices and application to monitor the patient critical physiological data. Sensors and the Bluetooth chip are been attached to E-health shield which in turn connected to the Arduino Uno and is utilized only for small path transmission and reception between the Arduino and mobile device.

3. Proposed Methodology

Figure 1. shows the implementation of the system. The core objective of the unit is to prognosticate the unidentified and untreated health issues by easily wearable health monitoring system mainly for the elderly patients. This system differs from other wearable health monitoring systems by including all the three sensors—temperature sensor, respiratory sensor, and heartbeat sensor. The sensors embedded in the wearable belt will sense the heart rate (pulse rate), temperature rate, respiratory rate of the patient. The LCD will display the output for reference and the buzzer will intimate as an emergency alarm for checking the health of the person.

![Figure 1. Block diagram of the proposed System](image)

The sensors connected to the microcontroller of the Arduino provide the output data of the patients. An optimum estimate value is fixed at the initial stage, when it exceeds the limit a warning report data will be transmitted to patient’s family members and doctors for emergency situations using GSM.
module and IOT cloud. Based on the health status, the doctor can decide the condition of the patient and appropriate medications will be provided. The system will predict the possibilities of getting affected by heart attacks, corona virus, asthma etc. and will help in maintaining regular health check-up and reduces death rate.

The proposed method is followed by hardware and software descriptions. The following section explains about the hardware components, specifications, and software descriptions in the proposed system. The important components are temperature, heartbeat and pulse sensor, GSM module, Arduino Controller.

3.1. Temperature Sensor
The LM35 temperature sensor (Figure 2) can be used to measure the body temperature more easily. The range of temperature is between (-55°C to 150°C), 0.1°C resolution precise. It is chosen for its cheaper cost and for easier availability. The LM35 does not have a temperature sensitive resistor like a thermistor. The temperature sensor works based on diodes; with the help of diodes the temperature changes the voltage at a known rate. The sensor will measure small changes and will provide an output of an analog voltage between 4 and 20V DC based on the measurements. The three pins of the sensor are connected to the GROUND, power supply (+5V) to Vs and any analog pin on the Arduino.

![Figure 2. Circuit Diagram of Temperature Sensor](image)

3.2. Heartbeat Sensor
The HeartBeat Sensor (Figure 3) is used to measure the rate of heartbeat. To find the heart rate (Pulse rate), the person under investigation’s finger is kept in the heartbeat sensor it measures the heart rate (pulse rate) and coverts the data as an analog output. Heartbeat sensor is based on the principle of light modulation. When the IR signals are allowed to fall on the finger vein due to blood flow, light amplification getting changed. According to the principle of heartbeat sensor, the changes in the intensity of light passing through the organ will measure the changes in the volume of blood in an organ. IR LED will be used as the source of light in heartbeat sensor and any Photo diode will be used as a detector. The sensor has its own clip where we can insert our finger and this sensor also has three pins for connecting VCC, GND and the data. The pulses will be read by the Arduino, it will measure the heart rate and display it in LCD. Heartbeat sensor output is transmitted to the Arduino with the output pin, LCD is connected to Arduino in the 4-bit mode.
3.3. **Respiratory type of sensor**

Respiratory type of sensor is integrated into the system and number of breaths per minute is counted and noted. If the patient is exposed to high pollution it alerts and helps in prevent attacks. Thus, the respiratory sensor is immensely helpful in monitoring patients with asthma, chronic bronchitis etc. The sensor is available in affordable cost and comfortable for elderly having long sleep sometimes. It will be easily wearable for the elderly. The wearable device is made as a belt around the chest of the patient which will monitor their respiratory rate.

![Respiratory sensor circuit diagram](image)

**Figure 4.** Respiratory sensor circuit diagram

The breath rate sensor is provided with 50 k thermistor in a voltage divider biasing circuit as shown in **Figure 4**. The value of change of resistance in the thermistor is monitored which is a function of inhale or exhale of oxygen/air. Also, the output is an ac signal in which dc components are eliminated by using the band pass filter. The range that be measured using this sensor is between 5 to 50 breaths/min. The output is suitably signal conditioned and send to the Arduino controller for further control action. The sensing element induced by inhaling and exhaling is measured by displacement variations. The sensor has elastic strap which can be adjusted according to the length and needs of the person. It determines chest contraction, and the output must be in a waveform.
3.4. **GSM Module**

GSM is an open technology used as communication bridge for transmitting voice and data service operating at different frequency bands ([Figure 5](#)). GSM is developed using the technique of time division multiple access (TDMA) for communication. The input will be divided into 8 timeslots for transmitting and receiving data. TDMA technique is used to avoid the traffic over multiple data at the same time. The data rate transmission is between 64 kbps to 120 Mbps. GSM module consists of mobile system, base station subsystem, network subsystem. The system will instruct the user via SMS and meets the needs and requirements of the user. Security alert is also achieved with end to end encryption of data. The user can call at anytime from anywhere which is the most efficient feature and simply GSM is a mobile phone which need SIM card to identify themselves for a network. GSM module that works Via GPS module to send the location information and output processed data as message to the family members or to the registered health centre.

![Figure 5. GSM Module](image)

3.5. **ARDUINO UNO**

Arduino Uno consists of multiple digital and analog input/output pins. Arduino is used to connect the sensors; thus, it is a microcontroller board with 14 pins. The controller is used to collect the data from the sensors, process the integrated data and generate the output through the LCD display to alert the present health condition of the elderly. The communication with a computer can be done by Arduino, another microcontrollers or Arduino board. The ATmega328P microcontroller are provided with the serial communicator, crystal oscillator, USB port, and voltage controller that is used to control the voltage level of the microcontroller. The serial pins 0 (Rx) and 1 (Tx) are used for the transmission and reception of data. Arduino IDE when connected to board using the external USB wire is meant for programming. The input to the controller may be connected using various sensors and actuators. The reference analog value may be in between 0 and 5V. Uno controller module is shown in [Figure 6](#).

![Figure 6. ARDUINO Module](image)
### Overall Hardware Specifications

The overall hardware specifications is shown in the Table 1.

**Table 1. Hardware Specifications**

| Module            | Item                              | Specifications                      |
|-------------------|-----------------------------------|-------------------------------------|
| Controller        | Operating voltage, digital pins,  | 5V, 14, 32KB                        |
|                   | Flash memory                      |                                     |
| Temperature       | Temperature range, power, output  | -55°C to 150°C, 4-30V,              |
| Sensor            | impedance                         | 0.1W for 1mA load                   |
| Heartbeat sensor  | LED, Gain, Power                  | 100, 3.3 V                          |
| Respiratory       | Bandwidth, Consumption            | 0 to 15Hz, 4mA                      |
| LCD               | Power, Display                    | 5V, plasma display                  |
| Buzzer            | Rated Voltage, Operating Voltage  | 6V, 4 to 8V, <30mA,                |
|                   | Rated Current, Resonant           | -2300Hz                             |
| GSM module        | Voltage, Low Power                | 5V, 1.5mA,                          |
|                   | Consumption, Operating            | 40°C to 85°C                        |

3.6. Flow Chart

Figure 7 represents the working flow of the human health monitoring system. The results would be analyzed for any critical conditions and immediate action would be taken accordingly. This system also helps in predicting the health of the patient well in advance to avoid any emergency conditions. Thus, remote monitoring and alerting system in the new era is achieved with the development of wireless and wearable technology.

![Figure 7. Flow chart of the Proposed System](image-url)
3.7. **IOT Platform**
The IOT Platform is used to transfer the collected, processed data from the controller to the cloud through any internet source. The data reaches to the doctor’s and other closest people of the patient. Based on the processed data speed the IOT hardware system will collect the information of the data and respond to the instructions. The following activities done using the IOT software as data collection, data processing, storage, and evaluation of the instructions. In data collection, the data given by the Arduino using the sensors which is processed in the microcontroller and the data is stored and programmed. Also, the device integration ensures that all the components of IOT are well integrated. In IOT based healthcare, patient health condition prone to any chronic disease is evaluated and predicted. With the help of GSM, transmission of collected information reaches to the destination i.e. any health centre or people of close contact. An immediate warning for any emergency is also incorporated. Google Cloud IOT platform is used and using HTTP’s the analysis of the real time data with security to the patient is done.

4. **Results and Discussion**
The output from temperature, heartbeat and respiratory sensor are tested individually and integrated output for the patient is collected and transmitted to the health center and people of close contact. The overall control is by the Arduino controller and data transmission using IOT cloud platform. The output from the temperature sensor is tabulated below in Fahrenheit (Table 2) and Celsius (Table 3).

| Table 2. Temperature sensor output (Degree Fahrenheit) |
|-----------------------------------------------------|
| **Test** | **Normal Value** | **Tested Value** | **Result** |
| Patient 1 | 97°F to 99°F | 100.4°F | Abnormal |
| Patient 2 | 97°F to 99°F | 95°F | Abnormal |
| Patient 3 | 97°F to 99°F | 98°F | Normal |

| Table 3. Temperature sensor output (Degree Celsius) |
|----------------------------------------------------|
| **Body Temperature** | **Status** |
| Less than 36°C | LOW - Unstable |
| 36°C TO 38°C | NORMAL - Healthy |
| 38°C and above | HIGH - Abnormal |

**Graph of Temperature Sensor**
The output temperature values are tabulated, and the corresponding graph is shown in **Figure 8**. If the temperature goes below 95°F (36°C) the person will be in the state of hypothermia and the healthy person temperature range is between 36°C to 38°C and unhealthy if goes beyond 38°C.

**Figure 8. Temperature Graph**
The output from the heartbeat sensor is tabulated below (Table 5 – Reference & Table 5). If the pulse rate is below 60 or above 100 BPM the person must go for medical advice. If the output of heartbeat sensor is in between 60 to 100 Beats Per Minute, the person health is normal.

**Table 4. Heartbeat sensor output (Reference Table)**

| Pulse Rate          | Status       |
|---------------------|--------------|
| Less than 60 BPM    | LOW - Unstable|
| 60 BPM To 100 BPM   | NORMAL - Healthy |
| More than 100 BPM   | HIGH - Abnormal |

**Table 5. Heartbeat sensor output**

| Test    | Normal Value | Tested Value | Result   |
|---------|--------------|--------------|----------|
| Patient 1 | 60 to 100 beats | 106 beats | Abnormal |
| Patient 2 | 60 to 100 beats | 80 beats | Normal   |

**Graph of Heartbeat Sensor**
The output of heartbeat sensor values is tabulated, and the corresponding graph is shown in Figure 9. The graph also explicit the normal and abnormal values in terms of Beats Per Minute.

![Graph of Heartbeat Sensor](image)

**Figure 9. Heartbeat sensor Output Graph**

The output from the respiratory sensor while resting condition is tabulated below (Table 6- Reference, Table 7). If the person breathes at a rate of value below 12 BPM or above 25 BPM, the person condition is abnormal and needs a medical advice. If the output of respiratory sensor is in between 12 to 25 Breadths Per Minute, the person health is normal.

**Table 6. Respiratory sensor output (Reference Table)**

| Breathing Rate (Breaths Per Minute) | Status |
|-------------------------------------|--------|
| Less than 12                        | LOW    |
| 12 to 25                            | NORMAL |
| More than 25                        | HIGH   |

**Table 7. Respiratory sensor output (Breaths Per Minute)**

| Test    | Normal Value | Tested Value | Result   |
|---------|--------------|--------------|----------|
| Patient 1 | 12 to 25     | 23           | Normal   |
| Patient 2 | 12 to 25     | 10           | Abnormal |
| Patient 3 | 12 to 25     | 25           | Abnormal |
Graph of Respiratory Sensor

The output of respiratory sensor values is tabulated, and the corresponding graph is shown in Figure 10.

Figure 10. Respiratory sensor Output Graph

The graph explicit the normal and abnormal values in terms of percentage output with respect to time. Red colour denotes the abnormal pattern and blue colour shows the normal pattern for healthy persons.

In Figure 11, the overall monitoring circuit for pulse rate and temperature measurement is shown. The LM35 temperature sensor and Heart rate grove sensor is connected to the controller Arduino. The sensors have three pins for connecting VCC, GND, data and the microcontroller will process the data to be sent to the patient’s closest members and to the doctor using the GSM module and cloud server. The data is collected and processed using the controller. The doctor can view the health of patient by using unique ID of the patients. The temperature sensor will give an output based on the voltage across the terminals. Contact type temperature sensors are used to detect the temperature. The principle of temperature sensor is when the temperature exceeds the threshold value it gives HIGH output, when the temperature drops below the value, it gives LOW output. The heartbeat sensor will give an analog output when the patient places his/her finger on the clip attached with the sensor. The principle of this sensor is that it gives an output based on the light modulation and calculate the pulse rate based on intensity change. The respiratory sensor will be attached to belt/collars which will sense the breathing rate, BPM. Glow of white LED indicates for low heart rate and yellow indicates high values. Also, the body temperature by red LED is abnormal high value and green indicates the lowest value.

Figure 11. Overall monitoring circuit for pulse rate and temperature measurement

Figure 12. depicts the connection diagram of respiratory sensor with Arduino controller.
After performing the sensor operations, the data will be collected and stored and transmitted to the hospital end for further actions. Any emergency, treatment would be given accordingly. The SMS alert message for a sample is shown in the Figure 13. Currently the alert message is giving the output of temperature, heartbeat and respiratory sensor output depending on the reference values of each vital parameters. The output is transmitted to the patient’s contacts and emergency calls. For any abnormal values, the patient health would be monitored in contact mode.

5. Conclusion and Future works
Smart health monitoring system for elderly is proposed and implemented to monitor the basic vital body parameters like body temperature, heart rate and some measures of patient’s condition as respiratory rate. The devised system checks the vital parameters and signs of the person under consideration and further processed using the integration unit of sensors, GSM wireless network system. The patient’s wireless health monitoring reduces the time consumption in gathering the patient’s data, more accurate than the manual system. The transmitted data is stored, analysed with proper analytic tool, and based on the report, the prediction of progress of diseases are done. This wearable device, in turn avoid the risky situation of patients with systemic organ diseases like heart, kidney and respiratory diseases. By using IOT devices combined with cloud environment, the database is shared to the hospital for further treatment and intensive care. Patients could be benefited by sitting in home itself, the basic tests and regular check-ups can be done and could avoid visiting the clinic frequently especially during this Covid period. Positively, the death rate of patient’s could be prevented, and treatment can be introduced at the right time to the needy. As a future work, this
wearable device could be further enhanced with more features like reduction in size, more vital parameters and with less cost.

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