Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 4, 2020

Review Article

IOT BASED HEALTH MONITORING SYSTEM

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Received:* 05.*12.2019 ***Revised:* 08.*01.2020*** ***Accepted:* 10.*02.202*0**

Abstract
Healthcare is given the extreme importance now a- days by each country with the advent of the novel corona virus. So in this aspect, an IoT based health monitoring system is the best solution for such an epidemic. Internet of Things (IoT) is the new revolution of internet which is the growing research area especially in the health care. With the increase in use of wearable sensors and the smart phones, these remote health care monitoring has evolved in such a pace. IoT monitoring of health helps in preventing the spread of disease as well as to get a proper diagnosis of the state of health, even if the doctor is at far distance. In this paper, a portable physiological checking framework is displayed, which can constantly screen the patient's heartbeat, temperature and other basic parameters of the room. We proposed a nonstop checking and control instrument to screen the patient condition and store the patient information's in server utilizing Wi-Fi Module based remote correspondence. A remote health monitoring system using IoT is proposed where the authorized personal can access these data stored using any IoT platform and based on these values received, the diseases are diagnosed by the doctors from a distance.

Keywords: Internet of Things, Health, Sensors.

DOI: http://dx.doi.org/10.31838/jcr.07.04.137

INTRODUCTION

Health is always a major concern in every growth the human race is advancing in terms of technology. Like the recent corona virus attack that has ruined the economy of China to an extent is an example how health care has become of major importance. In such areas where the epidemic is spread, it is always a better idea to monitor these patients using remote health monitoring technology. So Internet of Things (IoT) based health monitoring system is the current solution for it [1].

Remote Patient Monitoring arrangement empowers observation of patients outside of customary clinical settings (e.g. at home), which expands access to human services offices at bring down expenses [2]. The core objective of this project is the design and implementation of a smart patient health tracking system that uses Sensors to track patient health and uses internet to inform their loved ones in case of any issues. The objective of developing monitoring systems is to reduce health care costs by reducing physician office visits, hospitalizations, and diagnostic testing procedure [3]. Each of our bodies utilizes temperature and also pulse acknowledging to peruse understanding wellbeing. The sensors are linked to a microcontroller to track the status which is thus interfaced to a LCD screen and additionally remote association with have the capacity to exchange alarms. If framework finds any sudden changes in understanding heart beat or body temperature, the framework consequently alarms the client about the patients status over IOT and furthermore indicates subtle elements of pulse and temperature of patient live in the web. In this manner IOT set up tolerant wellbeing following framework viably utilizes web to screen quiet wellbeing measurements and spare persists time. There is a significant capability between

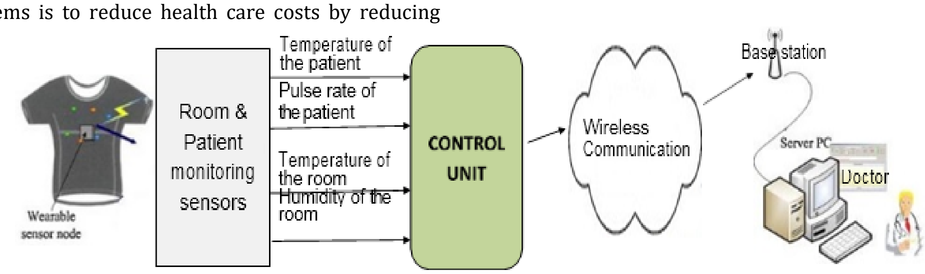

Fig. 1: Proposed System

SMS based patient flourishing viewing and IOT based patient checking framework. In IOT based framework, subtle parts of the patient flourishing can be seen by different clients [4]. The explanation behind this is the information should be checked by passing by a site or URL. While, in GSM based patient viewing, the flourishing parameters are sent utilizing GSM by strategies for SMS.

In most of the rural areas, the medical facility would not be in a hand reach distance for the natives [5]. So normally the people neglect any kind of minor health issues which is shown in early stages by variation of vital elements like body temperature, heartbeat rate etc. Once the health issue has been increased to a critical stage and the life of the person is endangered, then they take medical assistance, which can cause an unnecessary waste of their earnings. This also comes into account especially when certain epidemic is spread in an area where the reach of doctors is impossible. So to avoid the spread of disease, if a smart sensor is given to patients, who can be monitored from a distance would be a practical solution to save many lives [6].

In this paper section II describes about the proposed system, section III describes about the experimental setup including the circuit and section IV about the algorithm used in the implementation. The paper discusses the experimental results in section V.

PROPOSED SYSTEM

The core objective of this project is the design and implementation of a smart patient health tracking system. Fig.1 shows the overview of the proposed system. The sensors are embedded on the patient body to sense the temperature and heartbeat of the patient. Two more sensors are place at home to sense the humidity and the temperature of the room where the patient is staying. These sensors are connected to a control unit, which calculates the values of all the four sensors. These calculated values are then transmitted through a IoT cloud to the base station. From the base station the values are then accessed by the doctor at any other location. Thus based on the temperature and heart beat values and the room sensor values, the doctor can decide the state of the patient and appropriate measures can be taken.

Sensors

The temperature sensor connected to the analog pin of the arduino controller is converted into digital value with the help of ADC [10]. Using this digital data, the controller converts it into the actual temperature value in degree Celsius using the equation:

temperature (°C) = [raw ADC value*5/4095-(400/1000)]*(19.5/1000)

The heartbeat sensor is based on the principle of photo phlethysmography. It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ (a vascular region) [7]. The digital pulses are given to a microcontroller for calculating the heat beat rate, given by the formula:

BPM (Beats per minute) = 60*f, where f is the pulse frequency

A humidity sensor (or hygrometer) senses, measures and reports both moisture and air temperature. Humidity sensors work by detecting changes that alter electrical currents or temperature in the air. The relative humidity is calculated as given below:

Voltage = (ADC Value/1023.0)*5.0;

Percent relative humidity = (Voltage-0.958)/0.0307;

IoT Server

At whatever point the patient goes to the healing center premises, sensors sense the physiological signs and these signs are changed over to electrical signs [8]. Then simple electrical flag is changed over to advanced flag (computerized information) which is put away in RFID. The put way computerized information is transmitted through Zigbee Protocol to the neighborhood server Zigbee is appropriate convention for this framework. It comprises of greatest number of cell hubs. It is more favored for gadgets which are littler in measure and expend less vitality. From nearby server the information is exchanged to the therapeutic server through WLAN. Medicinal server comprises of substantial database as given in Table I. At the point when the information is exchanged to the therapeutic server, it checks whether the patient has any past medicinal record then the server adds the new information to that record and exchanges to the specialist. In the event that patient does not have any past therapeutic record then the server makes new ID and stores the information in its database [9]. This information is exchanged to the specialist for diagnosis. The complete Data transmission using IoT is given in Fig. 2.

Table I: Database Structure

Sensor data	Datatype
Patient ID	Int
Body Temperature	Float
Pulse rate	Float
Room temperature	Float
Room humidity	Float

Fig. 2. Data Transmission using IoT

EXPERIMENTAL SETUP

The body temperature, humidity and pulse rate sensors are monitored and initially displayed on LCD as explained in the flowchart in Fig. 3 [10 – 29]. The values from the sensors especially the body temperature sensor and the pulse rate sensor is stored in the database. For body temperature, the range is defined as in Table II. The membership function of the temperature range as in Fig. 4 can be explained as:

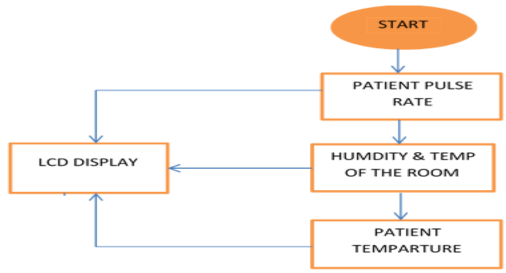

Fig. 3: Sensors Monitored

$$\text{Low} = \begin{cases} 1, & x < 36°C \\ 0, & x > 36°C \end{cases}$$

$$\text{Normal} = \begin{cases} 1, & 36.0°C \le x \le 37.5°C \\ 0, & x > 37.5°C \text{ and } x < 36°C \end{cases}$$

$$\text{High} = \begin{cases} 1, & x > 37.5°C \\ 0, & x < 37.5°C \end{cases}$$

Table II: Body Temperature

Body Temperature	State
36.0 –37.5 °C	Normal
>37.5 °C	High
<36.0 °C	Low

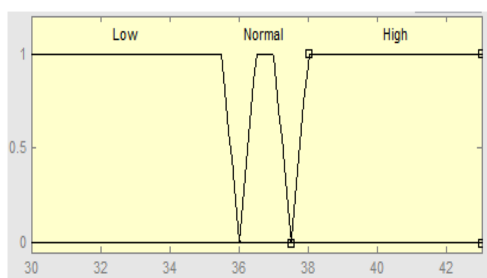

Fig. 4: Body Temperature membership function

Similarly, to determine the health state of the patient, different range of pulse rate reading is also considered [10] as in Table III. The membership function of the pulse rate in Fig. 5 is as given below:

$$\text{Low} = \begin{cases} 1, & x < 60 \text{ BPM} \\ 0, & x > 60 \text{ BPM} \end{cases}$$

$$\text{Normal} = \begin{cases} 1, & 60 \text{ BPM} \le x \le 100 \text{ BPM} \\ 0, & x > 100 \text{ BPM and } x < 60 \text{ BPM} \end{cases}$$

$$\text{High} = \begin{cases} 1, & x > 100 \text{ BPM} \\ 0, & x < 100 \text{ BPM} \end{cases}$$

Table III: Pulse Rate

Pulse rate	State
60 BPM - 100 BPM	Normal
>100 BPM	High
<60 BPM	Low

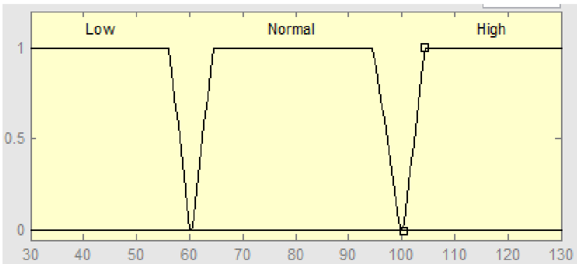

Fig. 5: Pulse rate membership function

Based on these different range values, the rules for diagnosing the disease of the patient is performed. The output health state is diagnosed with the following membership function: Healthy, Unwell, Hypothermia, Fever and Needs a detailed health checkup as shown in Fig.6. The membership function of the output health state is defined as given below:

$$\text{Checkup} = \begin{cases} 1, & x < 20 \\ 0, & x > 20 \end{cases}$$

$$\text{Unwell} = \begin{cases} 1, & 20 \leq x \leq 40 \\ 0, & x > 40 \text{ and } x < 20 \end{cases}$$

$$\text{Hypothermia} = \begin{cases} 1, & 40 \leq x \leq 60 \\ 0, & x > 60 \text{ and } x < 40 \end{cases}$$

$$\text{Healthy} = \begin{cases} 1, & x > 80 \\ 0, & x < 80 \end{cases}$$

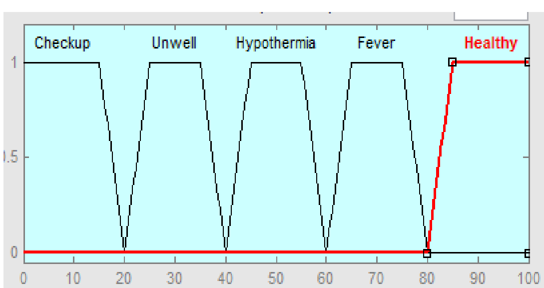

Fig. 6: Output Health State membership function

The rules for diagnosing the output health condition are as given in Table IV:

Table IV: Rules for Diagnosing Disease

Pulse rate	Body Temperature		
	Low	**Normal**	**High**
Low	Health Checkup	Unwell	Health Checkup
Normal	Hypothermia	Healthy	Fever
High	Health Checkup	Unwell	Health Checkup

These rules for diagnosis can be summarized by considering all the combinations of membership functions of the body temperature and the pulse rate as given below.

- If the pulse rate and body temperature are (Low & Low) OR (Low & High) OR (High & Low) OR (High & High)
- Then the patient has to immediately go for a detailed Health Checkup.
- If the pulse rate and body temperature are (Low & normal) OR (High & Normal), then the patient is considered to be unwell.
- If the pulse rate and body temperature are (Normal & Low) then the patient is considered to be in a hypothermia state.
- If the pulse rate and body temperature are (Normal & High) then the patient is considered to behaving fever.
- If the pulse rate and body temperature are (Normal & Normal) then the patient is considered to be healthy.

EXPERIMENTAL RESULTS

The body temperature sensor, pulse rate sensor, room temperature and humidity sensor values are calibrated using the microcontroller. The complete prototype of the health monitoring system with the sensors are shown in Fig. 5 and Fig.6,where it shows the output values of the sensors calculated and displayed in a LCD display, so that these values are visible even to the patient.

Fig. 7: Sensor Values displayed on LCD

Fig. 8: System Prototype

These sensor values are then sent to the database server. These data can be accessed from cloud by the authorized users using the IoT application platform. The sensor values of the patient is displayed in the application as shown in Fig. 8.

Fig. 9: Sensor Values Displayed on IOT Application Platform

Based on these values received, the disease of the patient is diagnosed by applying the rules set in Table IV. The diagnosis of the health state performed by the medical practitioner is shown in Fig 10. The medications can be prescribed and appropriate action can be suggested by the doctor even from a distance.

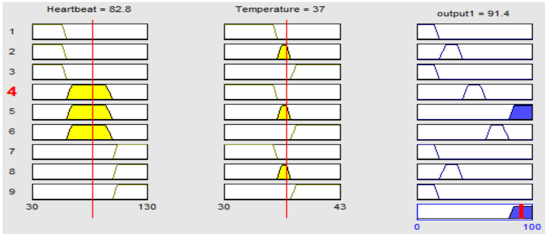

Fig. 10: Matlab Simulation Output for determining Health State

When the pulse rate value was taken as 82.8 BPM (Normal) and the body temperature as 37°C (Normal), then the output value of health state is 91.4, which comes in the membership function-Healthy. So for all combinations of the input sensors, the output health state can be simulated and diagnosed using the Matlab simulation.

CONCLUSION

The Internet of Things is considered now as one of the feasible solutions for any remote value tracking especially in the field of health monitoring. It facilitates that the individual prosperity parameter data is secured inside the cloud, stays in the hospital are reduced for conventional routine examinations and most important that the health can be monitored and disease diagnosed by any doctor at any distance. In this paper, an IoT based health monitoring system was developed. The system monitored body temperature, pulse rate and room humidity and temperature using sensors, which are also displayed on a LCD. These sensor values are then sent to a medical server using wireless communication. These data are then received in an authorized personals smart phone with IoT platform. With the values received the doctor then diagnose the disease and the state of health of the patient.

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