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Advancement of Smart Healthcare Monitoring Systems in an Internet of Things-based Environment

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Abstract

With the growth of technology, there have been many improvements in people's quality of life. New technologies have been implemented in the healthcare sector in one such area. Healthcare practitioners and experts are taking significant steps to use these emerging technologies to improve healthcare delivery significantly. The IoT has been at the core of many emerging healthcare technologies, e.g., B. heartbeat sensors, EKGs, and blood pressure sensors, each having different microcontrollers that read data from the sensors, which can be interpreted as needed. Advantageously, healthcare services have become quite expensive for people. That being said, most people need help understanding how these advanced healthcare systems work. As a result, they have to rely on doctors to understand what is being inferred constantly. Therefore, to combat this increasing problem, we have developed a remote healthcare system that uses sensors to derive the patient's vital signs and makes this data more accessible to the general public. Our primary focus was to work on a simplified mechanism to help the patient's family to check the patient's condition continuously. The device will be able to calculate the BMI, Body temperature of the Individual, Human Detection for Social Distancing, and give Medical Reminders.

In summary, the health monitoring system works so that the controller collects data via sensors and sends them to the cloud. The data is then processed and examined for remote viewing. The analyzed data will be sent to the guardians, doctors, and family members for viewing.

1. Introduction

As there is a substantial growth in the number of health risks today, the causes have also been rising due to eating habits, physical inactivity, and alcohol, among others. Many early signs can be detected which pertain to health risks in an individual. (Zholdas, Postolache, and Mansurova) Luckily with the growth and technology, there is a high chance for prognoses and treatment. It is essential to carefully monitor a patient's vitals to detect early signs.

Traditional testing at a specialized medical institution was the standard for a long time to determine blood sugar, blood pressure, and heart health. (Soam, Sharma, and N. Joshi) Due to the numerous running sensors that can read vital signs, such as blood pressure cuffs, glucose meters, heart rate monitors, and electrocardiograms, today's patients have the means to take their vital signs daily. (Morello et al.)

There are reasons why recording daily readings and keeping track of the recurring findings are essential, as they reveal the subject of future medical research. (Rejeb et al.) The Internet of things is being utilized increasingly in the healthcare sector to monitor and care for patients to improve people's quality of life. (Shreya, Chatterjee, and Singh)

It is crucial to utilize the benefits of technological advancements like the Internet of Things, which has emerged as an effective medium for the transfer of data from a hardware platform and allows full communication between people and machines to improve patient care quality. (Shalini)

A relatively new concept, the "Internet of Things," refers to the union of all network-connected devices that can be managed online, provide real-time information, and allow human engagement. The idea itself—which aims to share knowledge—was first put out by Kevin Ashton in 1998. (Navyashree et al.) In contrast, there are three ways to look at the Internet of things: through knowledge-oriented semantics, through object sensors, and through Internet-oriented middleware. Therefore, given the multidisciplinary character of the issue, such delimitation is justified. (Akram et al.) However, when integrating the three paradigms in the creation of applications, the value of the lot is evident. (M et al.)

While there are devices with storage, processing, and internal elements that should be smaller to increase efficiency today, the issues connected with this layer are related to shrinking. (Creaney, Reid, and Currie) The sensors used to assess diabetes, EKG, blood pressure, and other things are inaccurate, have big sizes, and require electricity. (Arslan and Candan)While dealing with those mentioned above from the application layer and services, several chances for collecting, processing, and suggesting crucial information for patients' sickness treatment and lifestyle changes are provided. (Nasr et al.)

This project's main idea is to develop an easily accessible solution for monitoring human vitals and portraying the same in a user-friendly manner.

The system architecture that we have developed consists of an Arduino Uno R3 microcontroller board, Liquid Crystal Display(16X2) (Nasser et al.), Temperature Sensor Chip TMP36 (Garg et al.), Ultrasonic Sensor(HC-SR04), and Passive Infrared Sensor. (Tunc)

The patient's body temperature is calculated using the temperature sensor. BMI calculation is done by taking the height(in cms) and weight(in kgs) of the person and giving the output along with the BMI category they fall into (underweight, normal weight, moderately overweight, overweight, severely obese). (Vaneeta Bhardwaj, R. Joshi, and Gaur) With the help of the Ultrasonic sensor, the device will be able to detect any humans present in the surroundings and display whether they have been detected. Those, as mentioned earlier, will be beneficial for social distancing. (Veeraiah et al.) The final feature of the device is a medicine reminder which takes in the input of the medicine reminder time(in hours, minutes, and seconds) and the current time(in hours, minutes, and seconds), and an alarm will be sounded to alert the user. (Mohapatra et al.)

Mentioned below is the methodology which involves the system architecture containing a detailed description of the various parts used and the workflow involved in the procedural aspect of the device. This is followed by the working of each sensor and their respective workflow charts. In conclusion, the advantages, results, and references are mentioned.

2. Materials and Methods

2.1. System Architecture:

The main objective of this device is to know the patient's vital signs daily and ensure that it is timely maintained.

The Internet of Things is applied in this project using the following components:

2.1.1. Arduino:

A detachable, dual-inline-package (DIP) ATmega328 AVR microprocessor serves as the foundation of the Arduino Uno R3 microcontroller board as shown in Figure 1. 20 digital input/output pins are included.

2.1.2. LCD:

Liquid crystal display, 16 x 2. (LCD)When showing a small quantity of data is required, embedded systems can employ the 16 x 2 liquid crystal display. Each of the two data lines on this display is broken

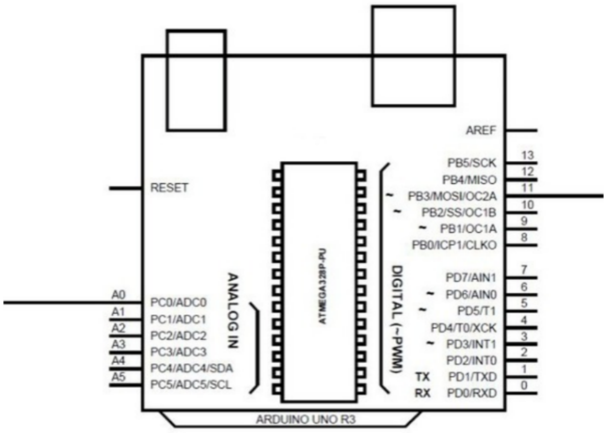

Fig 1. Arduino

FIGURE 1. Schematic diagram of Arduino board. Reprinted from Kumar, Deepak & Singh, Lovepreet & Virdi, Gagandeep & Singh, Gurleen & Channi, Harpreet. (2017). Designing and Modeling of Arduino-Based Light Sensor. 10.13140/RG.2.2.29499.31522.

into sixteen columns.

As shown in Figure 2, the LCD can show up to 32 characters in two rows: numbers, alphabets, or symbols. Similarly, by turning part of the cell's dots on and off, the LCD may also show certain user-created characters.

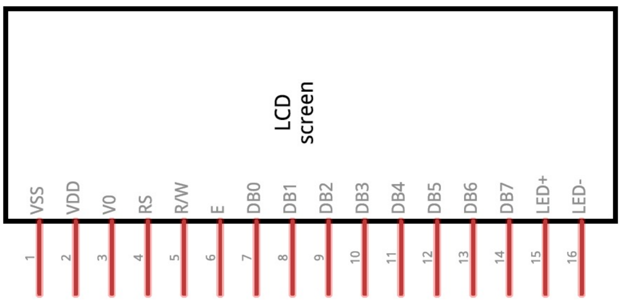

FIGURE 2. Schematic diagram of LCD. Reprinted from linuxhint, by Aaliyan Javaid, 2022, from https://linuxhint.com/lcd -16x2-pin-configuration.

2.1.3. Potentiometer:

A potentiometer, as shown in Figure 3, commonly called a pot or potmeter, is a three-terminal variable resistor whose resistance may be manually changed to regulate current flow. A voltage divider with adjustable steps is a potentiometer.

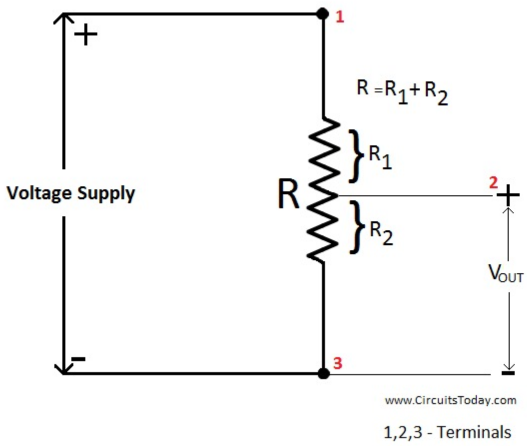

FIGURE 3. Schematic diagram of Potentiometer. Reprinted from linquip, by Anaa Lavaa, 2020, Retrieved from https://www.linquip.com0pt/blog /what-is-potentiometer/.

2.1.4. Temperature Sensor:

As shown in Figure 4, the temperature sensor chip TMP36 produces an analog voltage directly proportional to the Celsius temperature at the output. Then, using a scale factor of 10 mV/°C, convert this voltage to temperature. It has a shutdown feature that restricts the output current to less than 0.5 A. Up to 50 A of supply current can be obtained from it.

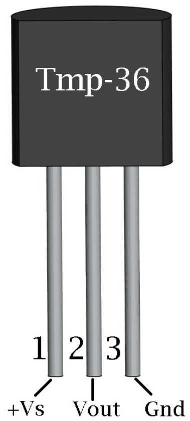

FIGURE 4. Schematic diagram of TMP 36 Sensor. Reprinted from instructables.com, by dhivaaa, Retrieved from https://www.instructa bles.com/ TMP36 - Temperature - Sensor-and-LCD-Display-Using-Ard/

2.1.5. Ultrasonic Sensor:

An ultrasonic sensor (HC-SR04), as shown in Figure 5, is a sensor that measures distance. An item or obstruction in its path will cause the ultrasound, which is emitted at 40 000 Hz (40kHz), to bounce back to the module. You may determine the distance by considering the sound's speed and travel time.

The HC-SR04 has four configuration pins: VCC (1), TRIG (2), ECHO (3), and GND (4). The supply voltage of VCC is +5V.

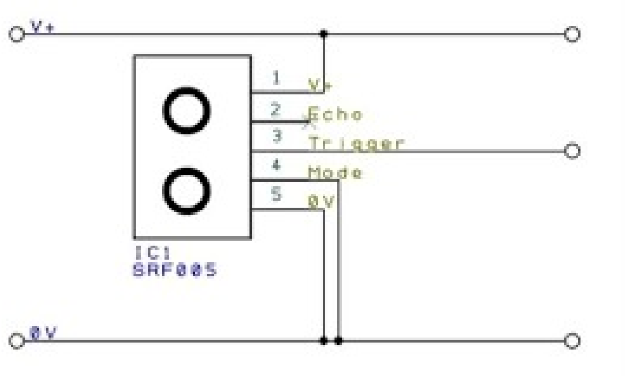

FIGURE 5. Schematic diagram of Ultrasonic Sensor. Reprinted from Karwati, K & Kustija, Jaja. (2018). Prototype of Water Level Control System. IOP Conference Series: Materials Science and Engineering. 384.012032.10.1088/1757-899X/ 384/1/ 012032.

2.1.6. Passive Infrared Sensor:

A practical module used to create various security alarm systems and motion detectors is the passive infrared sensor (PIR). It accepts infrared rather than emitting it. In essence, PIR sensors, as shown in Figure 6, look for changes in heat; anytime they do, their output PIN becomes HIGH.

The figure represents the pyroelectric sensor as the primary PIR sensor component (rectangular crystal behind the plastic cap). Also, some resistors, capacitors, and other parts are used to construct PIR sensors, like BISS0001 ("Micro Power PIR Motion Detector IC"). The BISS0001 IC processes the sensor's input to determine whether to set the output pin to HIGH or LOW.

2.2. Representation Diagrams of Smart Healthcare System:

Circuit diagram of the IOT system shown in fig 7.

2.3. Working:

2.3.1. Temperature:

The temperature sensor chip TMP36 produces an analog voltage directly proportional to the Celsius

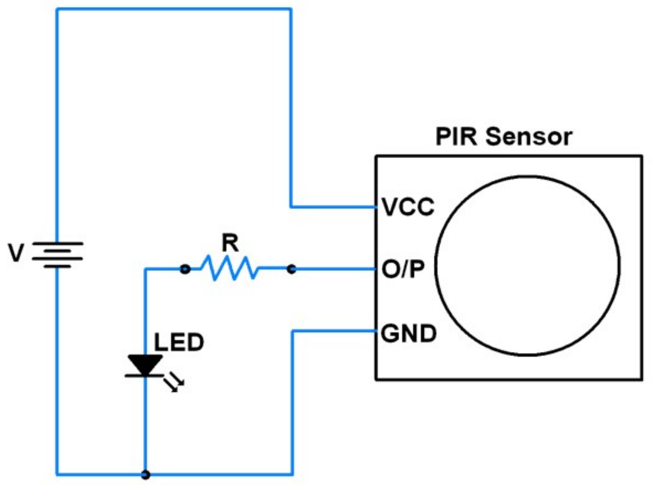

FIGURE 6. Schematic diagram of Passive Infrared Sensor. Reprinted from Arduino.cc, Retrieved fromhttps://support.arduino.cc/hc/en-us/articles/4403050020114-Troubleshooting-PIR-Sensor-and-sensitivity-adjustment.

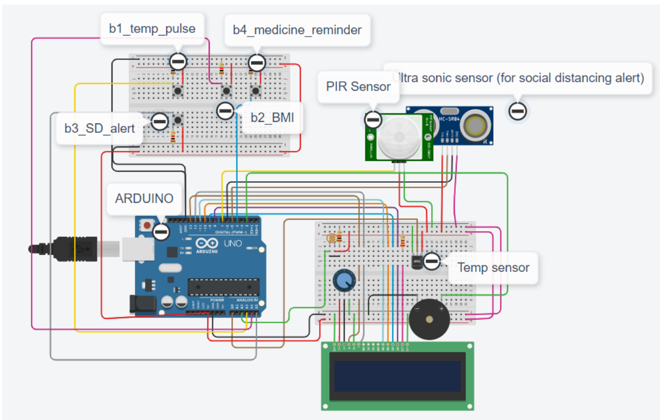

FIGURE 7. Circuit diagram of the IOT system.

temperature at the output, as shown in Figure 9. The temperature sensor chip is a TMP 36.

The voltage value is converted to Celsius after reading the analog value. If the Celsius value is >38, it shows a high temperature; otherwise, it is normal.

Formula:

$$voltage = analog(temp\ sensor) * 0.004882814$$

$$celsius = (voltage - 0.3) * 100$$

2.3.2. BMI:

Body Mass Index (BMI) is calculated by dividing a person's height in centimeters squared by their weight in kilograms. A high BMI may indicate high body fatness. A high BMI may indicate high body fatness. BMI does not make a body fat or health

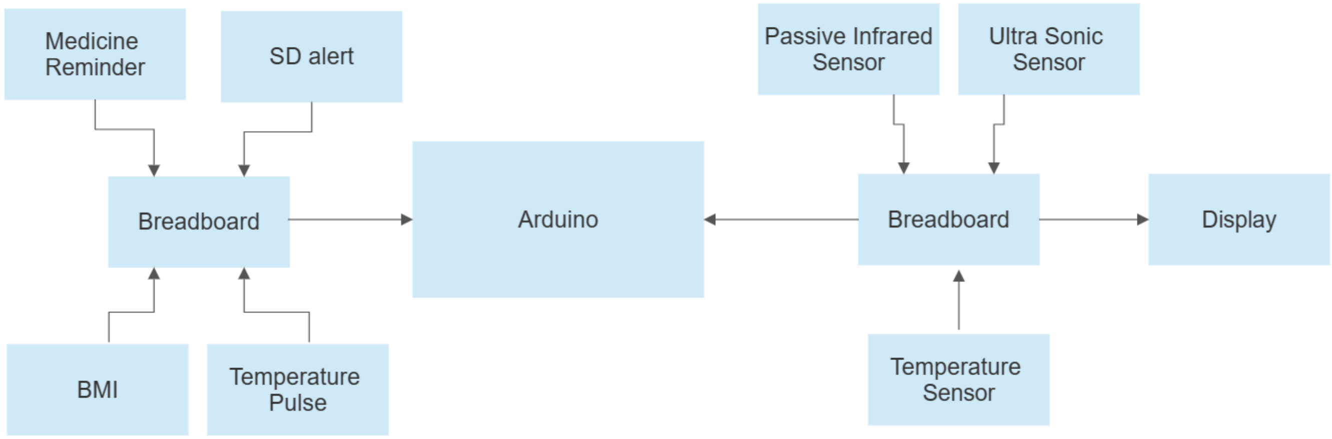

FIGURE 8. Block Diagram of the system.

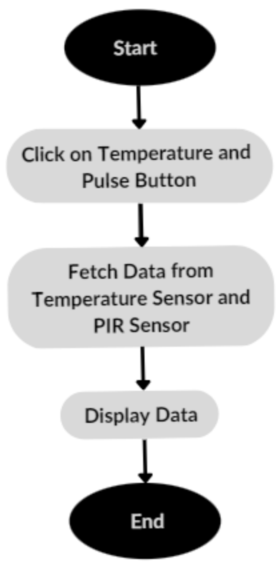

FIGURE 9. Flowchart representing the working of Temperature Sensor

diagnosis for a person, but it does screen for weight categories that may cause health issues.

To compute the user's respected BMI, it needs their input on relevant facts. This method asks users to enter their weight in kilograms and height in centimeters and calculates BMI, as shown in Figure 10.

BMI is determined using the following formula:

$$BMI = weight/\ (height)2 * 1000\ (or)\ weight * 10000/(height^2)$$

The output is divided into 5 cases:

1) If BMI is <18, then it gives output as underweight

2) If BMI is >18 and <25, then it gives output as normal

3) If BMI is >25 and <30, then it gives output as overweight

4)If BMI is >30 and <35, then it gives output as moderately overweight

5)If BMI is >35, then it gives output as severely obese

Classification of BMI is shown in table 1.

TABLE 1. Sample test for BMI

Height(in cms)	Weight(in kgs)	BMI value	Result
160	45	17.58	Underweight
172	65	21.97	Normal weight
180	85	26.23	Overweight
172	95	32.11	Moderately Overweight
143	75	35.68	Severely Obese

2.3.3. Medicine Reminder:

It serves as a reminder to take medications at the appointed times of morning and night. The users set the timing for these reminders. It requests the input

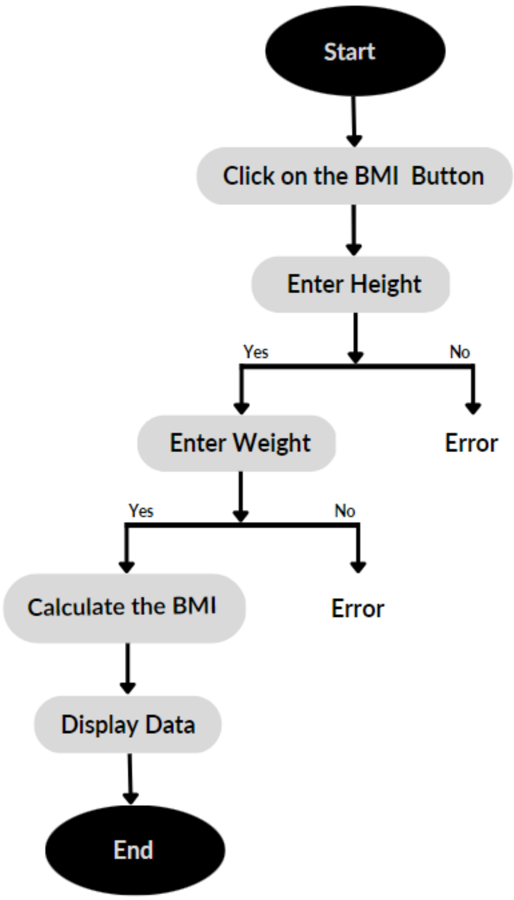

FIGURE 10. **Flowchart representing the working of BMI**

of time in the following format: hours, minutes, and seconds for both morning and evening.

It determines the current time by requesting the user's time, as shown in Figure 11.

Applying the equation:

$$(hours * 3600) + (mins * 60) + (seconds)$$

Subtracting the current time from it, it determines how long you have left to take the medication.

2.3.4. Social Distancing Alert:

Using an Ultrasonic sensor, we can detect the objects around us (in this case, humans) and notify the user about the obstacles. The flow diagram for the same is shown below in Figure 12.

3. Results and Discussion

In conclusion, our research has come down to understanding what means we can use to ensure that the primary hospitals' check-up facilities, such as temperature and BMI, can be monitored cost-effectively.

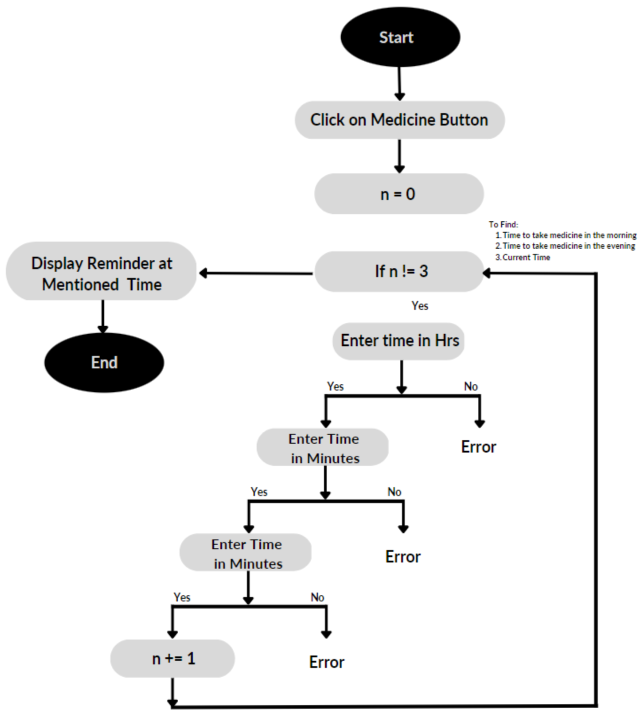

FIGURE 11. **Flowchart representing the working of Medicine Reminder**

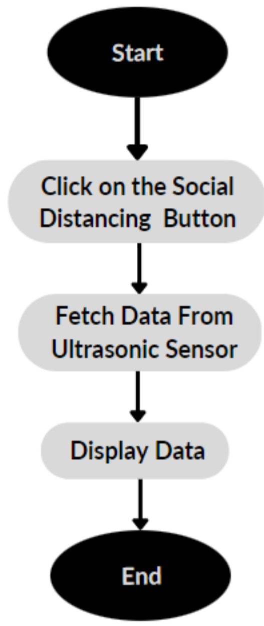

FIGURE 12. **Flowchart representing the working of Social Distancing Alert**

We have done this by using basic sensors that can be found easily in the market and integrating them to form one system that can simultaneously monitor and calculate multiple vitals.

The results and outputs are mentioned below:

3.1. Results:

Initial output for the monitoring system, when switched on:

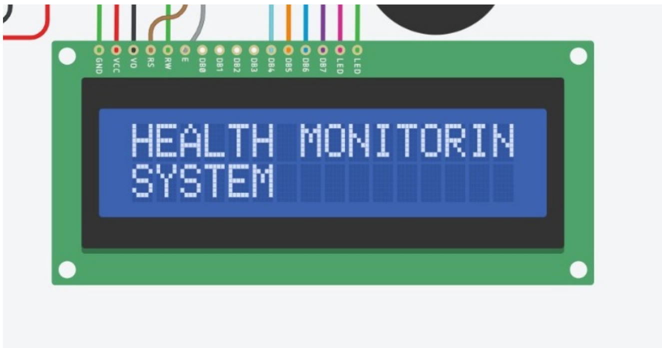

FIGURE 13. The output of the LCD when the device is turned on.

When the button for temperature pulse is pressed, it will initially calculate the current temperature of the person's body, as shown below in Figure 14. It will display it as shown in Figure 15.

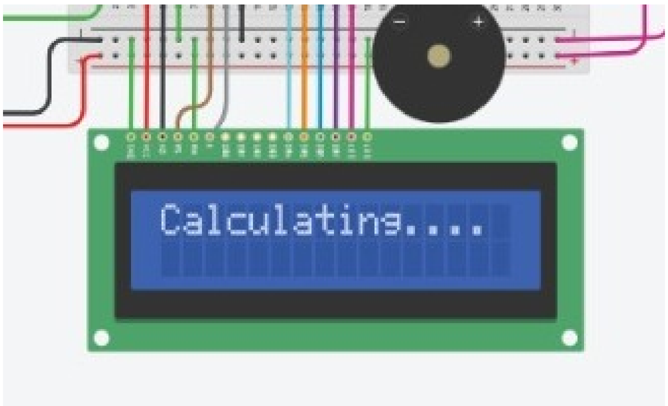

FIGURE 14. The output of the LCD is when the device calculates the temperature.

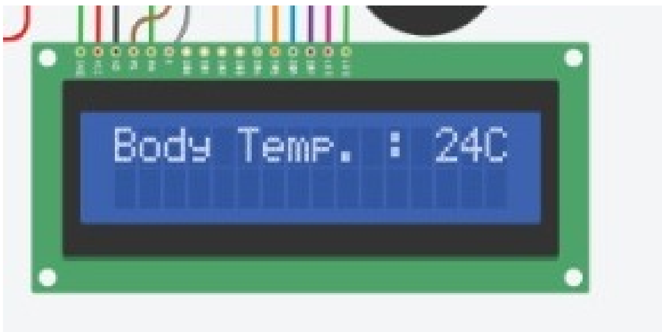

FIGURE 15. The output of the LCD is when the device shows the body temperature.

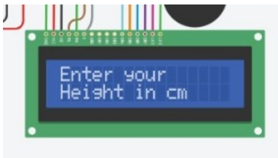

FIGURE 16. The output of the LCD is when the device asks the user to enter their height.

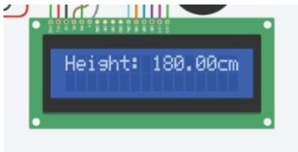

FIGURE 17. The LCD output when the device displays the user's height.

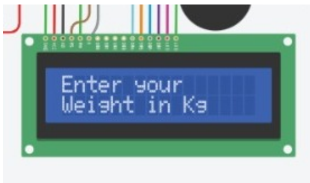

FIGURE 18. The output of the LCD is when the device asks the user to enter their weight.

FIGURE 19. The LCD output when the device displays the user's weight.

FIGURE 20. The LCD output when the device displays the user's BMI.

When the button for BMI is pressed, it will ask for the input of the height(in cm) as shown in Figure 16 and weight(in kg) as shown in Figure 18 of the person, and the BMI is calculated and displayed in

FIGURE 21. **The output of the LCD is when the device displays the detection of humans.**

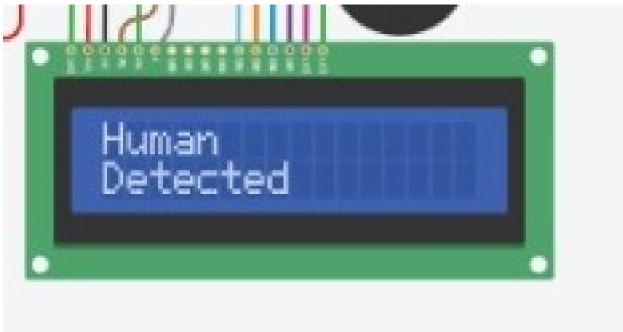

FIGURE 22. **The output of the LCD is when the device displays the detection of humans.**

FIGURE 23. **The output of the LCD is when the device displays the remainder of the time to take medicine.**

Figure 20.

When the alert button is pressed with the help of the PIR sensor and Ultrasonic sensor, the device can detect any objects present in the surroundings and display whether a human is detected, as shown in Figure 21, or not, as shown in Figure 22.

On pressing the medicine reminder button, input is asked when the medication should be taken, as shown in Figure 23. This is done by taking the input for the time of the day in the day (specified in hours, minutes, and seconds), and based on that, an alarm

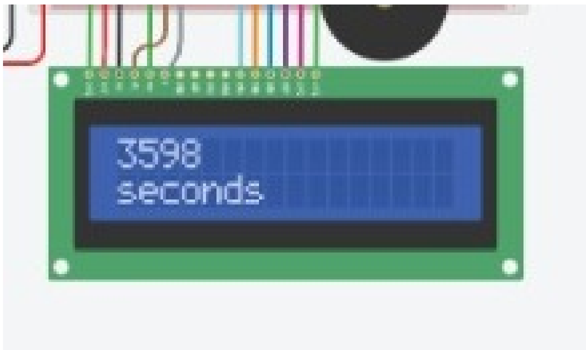

FIGURE 24. **The output of the LCD is when the device displays the remainder of the time to take medicine in seconds.**

will be sounded to alert the person to take the medication. Notification of when to take medicine, as shown in Figure 24, is also displayed.

4. Conclusion

The Internet of Things-based healthcare monitoring system helps patients with vital monitoring. This has a single motive of improving the quality of patient's life by assisting them in making everyday routines and keeping a constant eye on their vitals. This system accurately measures vitals, including BMI, Temperature, and Human Detection and Medicine Reminder.

5. Authors' Note

The Authors, Durga Abhiram Gorle, Durga Sritha Dongla, Rishita Kakarlapudi, and Dr. P Naresh, declare no conflicts of interest regarding the publication of this research article.

This is a plagiarism-free article with accurate results and information.

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