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# Design of Smart Health Monitoring System for Disease Detection

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## Abstract

*The most valuable asset is one's health. However, there isn't much free time for today's people to keep an eye on their health. A health monitoring system that tracks users automatically is necessary to alert users to their health status. Rapid advancement in internet and technology provides improvement in the health system. In the conventional method, people are required to visit their doctors on a regular basis for health checkups. The use of technology in the health monitoring system can save valuable time by having the health status automation. Additionally, the cloud, which revolutionized data transformation, contributes to the development of a better and more dependable health monitoring system. One of the most important technology-based systems has been healthcare monitoring systems. Humans struggle with the problem of premature mortality because people with various ailments don't receive promptmedical care. The main objective was to create a trustworthy smart health monitoring system so that medical professionals could keep an eye on their patients, whether they were in a hospital or at home, using the proposed integrated healthcare system to ensure better and more dependable care. A prototype of health monitoring system is created, and it will have a number of cutting-edge features that will revolutionize the healthcare sector, with less reliance on human labor and greater efficiency in tasks like temperature monitoring, ECG analysis, ambient temperature and humidity supervising, oxygen level recording, and BPM monitoring, this system will work autonomously. Body temperature, BPM, oxygen, temperature, and humidity sensors are included in the system to help maintain optimal health. The system's accuracy, reliability, sensitivity, usability, and scalability will be tested through comprehensive testing and validation in actual healthcare settings. This enables proactive and individualized health management. The results are anticipated to develop healthcare technologies and im- prove the standard of healthcare services.*

## Keywords

*Arduino UNO, BPM (Beats Per Minute), ECG (Electrocardiogram), Sensors, Prognosis*

## 1. Introduction

The globe has been greatly impacted by the rising usage of new technologies, computer-based portable embedded devices, and smart gadgets in the field of health. People can verify their normal everyday examinations at home. Additionally, this offers continuous monitoring to individuals in non-clinical settings. The advantages these technologies offer is progressively being embraced by health professionals, leading to a notable advancement in clinical healthcare. The World Health Organization (WHO)'s founding documents state that everyone has a fundamental right to the best possible level of health. As a result, I am genuinely inspired by this, and I attempt to put forth an innovative solution that puts forward a smart health monitoring system that uses sensors to track patient vital parameters and uses the internet to update the doctors so that they can help in case of any issues at the earliest possible stage preventing death rates. We should make every attempt to determine the cause of any serious ailment for which early detection and treatment would be beneficial as soon as possible. People can make important decisions about their care and support requirements, as well as financial and legal matters, while they are still able to do so thanks to prognosis. Individuals and their families can benefit when they receive pertinent information, advice, and guidance as they handle new situations. Mammograms avert 12,000 deaths annually across the country. Guide- lines for colorectal cancer screening would save 33,000 lives annually in the United States if men and women complied with them.

Health monitoring systems allow for health recording outside of traditional clinical settings, which may improve access to care and lower the cost of providing it. The quality of life for a person can be considerably enhanced by this. Patients are able to keep their freedom, avoid complications, and pay as little as possible out of pocket. This technology makes these objectives possible by sending care right to the patient's house. Patients and their families also feel more secure knowing that they are being watched over and will receive assistance if a problem arises.

## 2. Methodology

Here, Arduino UNO will be the main processing unit of the system prototype and will be utilized to manage all of its functions.

- The sensors, including the DHT11, AD8232, DS18B20 sensor, and MAX30100 sensors, need to be connected to the Arduino UNO using jumper wires and a breadboard. Each sensor will have specific pins that need to be connected to Arduino’s digital or analog pins.
- Once the sensors are connected, the Arduino will read the data from the sensors using the appropriate libraries and functions. For example, the DHT11 sensor will require a DHT library to read the temperature and humidity values.
- The data read from the sensors will be displayed on the 20x2 display. The display will show the user's body temperature, heart rate, blood oxygen levels, and heart rate values, ECG, ambient temperature and humidity in real-time.
- This system will be programmed for detection of any abnormal values in the user's health parameters. In case of any abnormalities, the system will alert the user with an audible alarm, or a visual message displayed on the 20x2 display.
- The health monitoring system will also be capable of logging and analyzing the user's health data over time. This will allow the user and healthcare professionals to track the user's health progress and detect any long-term trends or potential health problems.
- The health monitoring system will require a power source such as a battery or USB cable to power the Arduino UNO and the sensors.

Overall, the methodology for health monitoring using the components mentioned involves setting up the circuit, writing the code, testing the circuit, analyzing the data, alerting the user, and continuous monitoring.

## 3. Literature Survey

Malathi M et al [11] developed a project in which microcontroller serves as a communication gateway. This system proposes a clever patient health monitoring system that makes use of sensors to track patient health and the internet to notify worried doctors or concerned family members in case of an emergency. As a result, the current study focuses on designing an Internet of Things-based smart patient health tracking system utilizing an Arduino microcontroller. This uses a temperature sensor to measure the temperature and a pulse rate sensor to identify the heartbeat before sending the information to the cloud through the internet. In order for the patient to clearly understand their health state, this information is also relayed to the LCD display.

K. Haripriya et al [12] suggested that after major operations, patients' health state may be monitored via the Internet of Things (IoT) and cloud-based processing. In this model, the patient can be continuously monitored by gathering physiological data from various sensors, processing it on a PIC microcontroller, sending the results over GSM and an IoT module, and storing the results online. You can access the data from any location, and there won't be any issues even if you forget to submit a report while seeing a doctor. By entering the specific patient ID, he may access the information.

Priyanka Das et al [13] outlines the different advancements in patient monitoring system technology throughout the years. The method is implemented in the article by employing intelligent biosensors to identify and document the physiological traits of humans, and then connecting this data to a computer via wireless protocols to alert the physicians about the patient's health. A patient monitoring system can monitor a patient's physiological state constantly or periodically throughout time. It includes the periodic detection of regular vital parameters and the delivery of alerting signals when vital parameters point to any hazards or dangers.

IoT-based health monitoring programs by Naina Gupta et al [15] put forward a framework aimed at solving the problem of time wastage during ambulance services and hospitals, forcing data transmission via GSM module via Bluetooth technology. Regular medical examinations and monitoring of various body parameters with the help of different sensory connections are the main focus. They are focused on developing a small-size wearable system that can transfer data via GPRS to custom networks.

Harshitha Bhat et al [14] suggested a system in which a patient will be carrying hardware with sensors and an Android phone application in the proposed system. The patient's body temperature and heart rate will be sensed by the sensors, and these data will be sent to an Android smart phone over Bluetooth and WiFi. The patient's health is continually monitored in the currently proposed system using a separate sensor connected to the Ardiuno board, and the data collected is sent to the server using an ethernet shield also connected to the Ardiuno board. An alarm is sent to the doctor via an android application loaded on their smartphone if any of the parameter values exceed the threshold value.

M Khan et al [1] suggested Internet of Things (IoT) based smart health monitoring system is a new idea for Bangladesh. In Bangladesh almost 70 percent of people are living in rural areas. Instant access of proper healthcare service is very difficult for the rural people in Bangladesh. MBBS doctors and suitable healthcare-related facilities are not generally accessible inthe rural part of Bangladesh. People in rural areas of our country suffer very much for getting proper healthcare services. IoT based smart healthcare services are very important in our country, especially for rural areas. With the help of IoT based smart telemedicine healthcare services rural people are getting medical facilities staying at their own location. They do not need to travel far distances to get the medical consultation of MBBS doctors and basic medical tests. This system is helping rural people now to a great extent for medical treatment, consultation and medical testing purposes. It saves time, cost and travel of rural people. The health of remote patients is monitored, and treatment plans are provided from the city with the help of this system to this service.

## 4. Proposed System

The health monitoring system refers to a collection of tools, technologies, and processes which are designed to track and monitor an individual's health status. These systems are typically used to collect and analyze health data in real-time or periodically and can provide valuable information about an individual's overall health and well-being. These systems can vary in complexity, ranging from simple wearable devices such as fitness trackers or smartwatches, to more advanced systems that integrate multiple sensors, data analytics, and connectivity options. The main purpose of a health monitoring system is to continuously or periodically collect health-related data from an individual, analyze the data, and provide insights or notifications based on the findings. It is a digital platform designed to monitor and manage the health status of individuals in real-time. It utilizes cutting-edge technology to collect, analyze, and visualize health data, enabling proactive health monitoring and early detection of health issues.

Main objective of this project is to develop a smart health monitoring system using Arduino UNO, DHT11 Sensor, AD8232 Sensor, DS18B20 Sensor, MAX30100 Sensor, and a 20x2 display. This system will be designed to monitor all of these parameters in real-time and provide alerts to the user and healthcare professionals in case of any abnormalities. This project aims to provide an affordable and effective health monitoring solution that can be used by individuals in their homes, as well as in medical facilities.

## 5. Materials and Methods

**Table 1.** List of components required along with their use.

**Hardware Requirement**

| S. No. | Components | Use |
|---|---|---|
| **1** | Arduino UNO | It is a microcontroller board that acts as the brain of the Agriculture Robot. It receives input from various sensors and controls the output devices |
| **2** | AD8232 | This will measure the user's ECG value and detect any abnormalities in the heart's electrical activity |
| **3** | DS18B20 | This sensor will measure the user's temperature using a thermistor, which is a resistor whose resistance changes with temperature |
| **4** | MAX30100 | This measures the user's blood oxygen saturation levels and heart rate |
| **5** | DHT11 | This detects the ambient temperature and humidity |
| **6** | Jumper Wires | These are used for the connection of various components to the Arduino and other modules. |
| **7** | ECG Probe | This connects the human body to ECG sensor. It senses the electrical signals of heart |
| **8** | 20X2 LCD Display | It is used to display the content of parameters values |
| **9** | Thermometer Display | It is used to display the measured body temperature values |
| **10** | Power Source | A power source such as a battery or USB cable will be used to power the Arduino UNO and the sensors |

**Block Diagram**

The block diagram includes an Arduino UNO microcontroller that serves as the overall system's controller shown in Fig 1, sensors are employed to collect the data of health parameters and communicate with microcontroller. A power supply charging circuit that supplies 5V for the Arduino board, LCD display is connected to microcontroller, which displays the results obtained during operation of system, and ECG probe is also given for the ECG analysis.

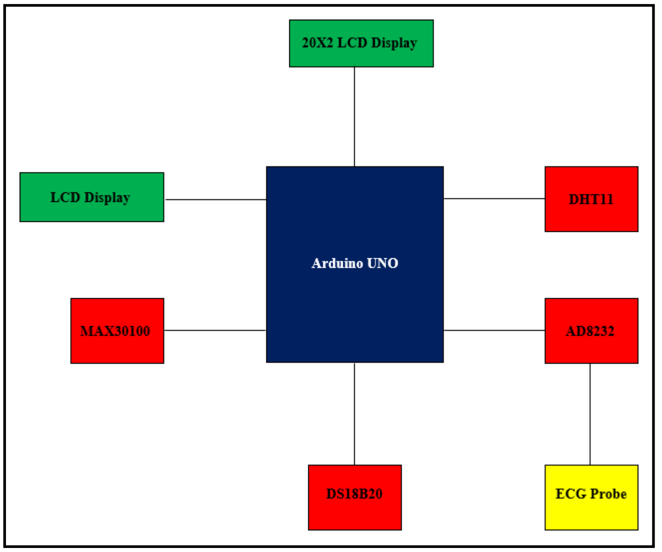


**Figure 1.** Overview of health monitoring system

**Implementation Details**

- The Arduino UNO, sensors, and a display are among the components that must be gathered in the initial step
- The circuit must then be configured using a breadboard or PCB. The proper pins on the Arduino UNO board must be linked to each sensor and the display
- The next step is to write the code for the Arduino board once the circuit is configured. The 20x2 display should show the values that the code has read from each sensor.
- The circuit should be tested after the code has been developed to make sure it is operating as planned. Making changes to the code or the circuit may be necessary
- The information gathered from the sensors can be analyzed to find any potential health risks once the circuit is functioning properly. For instance, the body temperature sensor can be used to identify fevers while the ECG sensor can be used to identify irregular cardiac rhythms
- Systems should be created to run continuously, allowing for the earliest possible detection of any potential health issues.

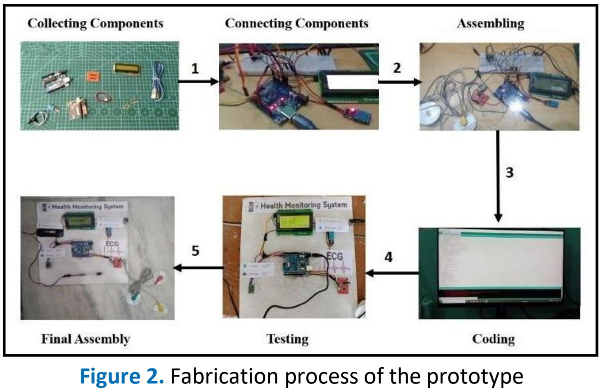


**Figure 2.** Fabrication process of the prototype

**Final Assembly**

The final assembly process is to have a clear understanding of the system requirements and specifications and selecting appropriate sensors or devices for each parameter. Determining the data, designing the user interface for showing findings, and adding any necessary features or functionalities that may measure parameters like body temperature, oxygen saturation, heart rate, and ambient temperature and humidity are all included in the system design. To make sure it complies with all criteria and specifications, should go through one final quality assurance inspection. This may entail examining each component to ensure correct operation, confirming the precision of measurements of health parameters, and validating the performance of the system in comparison to predetermined standards for its intended usage. Sensors and controllers are coupled to electrical components. The software is then loaded onto the controller system after all the parts have been put together. Depending on the complexity and characteristics of the system being put together, different procedures and requirements may be necessary. To guarantee a secure, precise, and trustworthy health monitoring system, it's critical to add here to accepted industry standards and best practices.

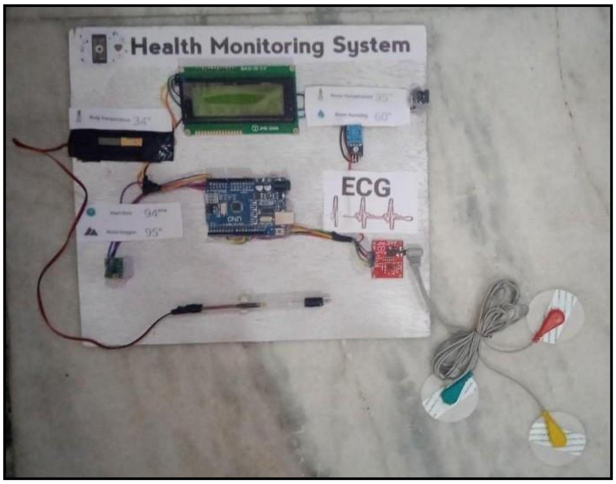


**Figure 3.** Final assembly of the prototype

## 6. Operations

**Ambient Temperature:** The system can be used for measuring the ambient temperature for which DHT11 sensor has been used. The sensor communicates with the microcontroller and the obtained result is displayed on the LCD display.
**Ambient Humidity:** The system can be used for measuring the ambient humidity for which DHT11 sensor has been used. The sensor communicates with the microcontroller and the obtained result is displayed on the LCD display.
**Body Temperature:** The system can be used for measuring the ambient temperature for which DS18B20 sensor has been used. The sensor communicates with the microcontroller and the obtained result is displayed on the LCD display. An attachment has been made at the front of the system, which a patient can extend and measure his/her body temperature.
**Oxygen Saturation:** The system is used to measure the heart rate for which MAX30100 sensor has been used. The sensor communicates with the microcontroller and the obtained result is displayed on the LCD display.
**Heart Rate:** The system is used to measure the heart rate for which MAX30100 sensor has been used. The sensor communicates with the microcontroller and the obtained result is displayed on the LCD display.
**Electrocardiogram:** The system is used to measure the heart rate for which AD8232 sensor has been used. The sensor communicates with the microcontroller and the obtained result is displayed on the LCD display. An attachment has been made at the front of the system, in which ECG probe can be connected and patient can stick them to measure his/her ECG.

## 7. Results and Analysis

The results and analysis of the health monitoring system can provide valuable insights into the health status of an individual. The system can collect various data points such as body temperature, heart rate, blood oxygen levels, and more. These data points can be analyzed and interpreted to provide meaningful information about the individual's health status.

**1. Body Temperature**

**Table 2.** Thermometer value and sensor value

| S. No. | Actual Value (°C) | Observed Value (°C) | Error (%) |
|---|---|---|---|
| 1 | 35.4 | 35.6 | 0.56 |
| 2 | 36.7 | 36.3 | 1.08 |
| 3 | 36.6 | 37.8 | 3.27 |
| 4 | 34.5 | 34.6 | 0.29 |
| 5 | 36.1 | 36.4 | 0.83 |
| 6 | 37.3 | 36.9 | 1.07 |
| 7 | 36.5 | 35.8 | 1.91 |
| 8 | 36.8 | 37 | 0.54 |
| 9 | 36 | 35.8 | 0.55 |
| 10 | 37 | 36.8 | 0.54 |

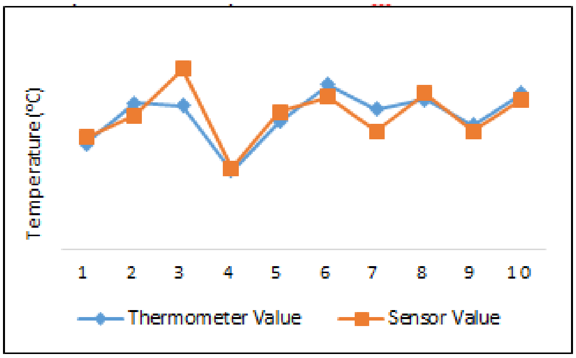


**Figure 4.** Actual temperature value vs observed value

**2. Oxygen Saturation**

**Table 3.** Oximeter value and sensor value

| S. No. | Actual Value (%) | Observed Value (%) | Error (%) |
|---|---|---|---|
| 1 | 96 | 95.5 | 0.52 |
| 2 | 97.5 | 97 | 0.51 |
| 3 | 97.5 | 97.5 | 0 |
| 4 | 98 | 96.5 | 1.53 |
| 5 | 95.5 | 96 | 0.52 |
| 6 | 97 | 97.5 | 0.51 |
| 7 | 96 | 99 | 3.12 |
| 8 | 96 | 96.5 | 0.52 |
| 9 | 97 | 96.5 | 0.51 |
| 10 | 97.5 | 96.5 | 1.02 |

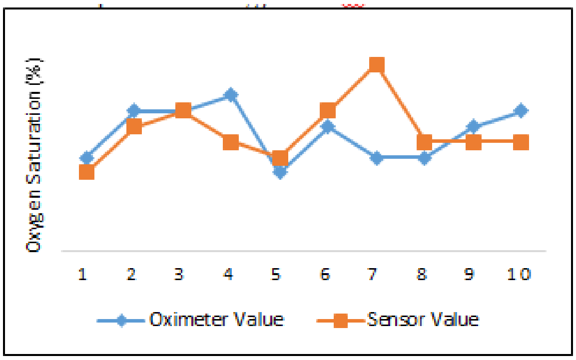


**Figure 5.** Actual oxygen level vs observed value

**3. Heart Rate**

**Table 4.** Pulse meter value and sensor value

| S. No. | Actual Value (bpm) | Observed Value (bpm) | Error (%) |
|---|---|---|---|
| 1 | 69 | 72 | 4.34 |
| 2 | 69.5 | 75 | 7.91 |
| 3 | 66 | 72.5 | 9.84 |
| 4 | 64.5 | 68 | 5.42 |
| 5 | 73 | 75.5 | 3.42 |
| 6 | 65 | 71 | 9.23 |
| 7 | 74 | 76 | 2.7 |
| 8 | 67 | 72 | 7.46 |
| 9 | 67 | 68.5 | 2.23 |
| 10 | 73.5 | 80 | 8.84 |

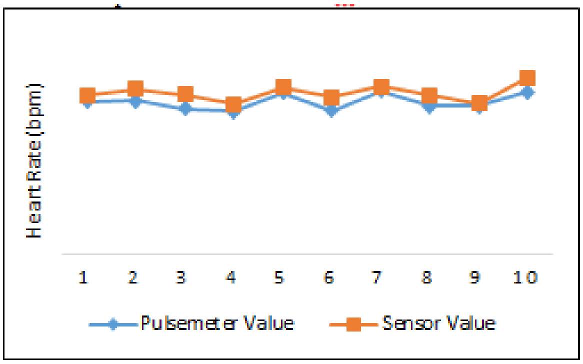


**Figure 6.** Actual heart rate vs observed value

### 4. Ambient Temperature

**Table 5.** Hygrometer value and sensor value

| S. No. | Actual Value (ºC) | Observed Value (ºC) | Error (%) |
|---|---|---|---|
| 1 | 34 | 33.8 | 0.58 |
| 2 | 37 | 35 | 5.4 |
| 3 | 35 | 34.2 | 2.28 |
| 4 | 40 | 38.6 | 3.5 |
| 5 | 34 | 33.3 | 2.05 |
| 6 | 33 | 33.7 | 2.12 |
| 7 | 35 | 34.3 | 2 |
| 8 | 39 | 40.3 | 3.33 |
| 9 | 37 | 38 | 2.7 |
| 10 | 34 | 34.5 | 1.47 |

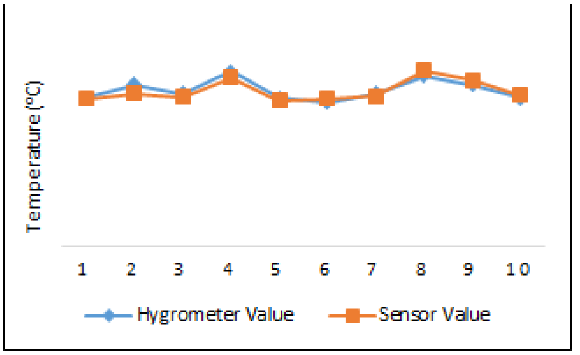


**Figure 7.** Actual temperature value vs observed value

### 5. Ambient Humidity

**Table 6.** Hygrometer value and sensor value

| S. No. | Actual Value (%) | Observed Value (%) | Error (%) |
|---|---|---|---|
| 1 | 48 | 50 | 4.16 |
| 2 | 42 | 40 | 4.76 |
| 3 | 42 | 44 | 4.76 |
| 4 | 45 | 48 | 6.67 |
| 5 | 40 | 41 | 2.5 |
| 6 | 38 | 39 | 2.63 |
| 7 | 35 | 34 | 2.85 |
| 8 | 42 | 41 | 2.38 |
| 9 | 46 | 47 | 2.17 |
| 10 | 41 | 42 | 2.43 |

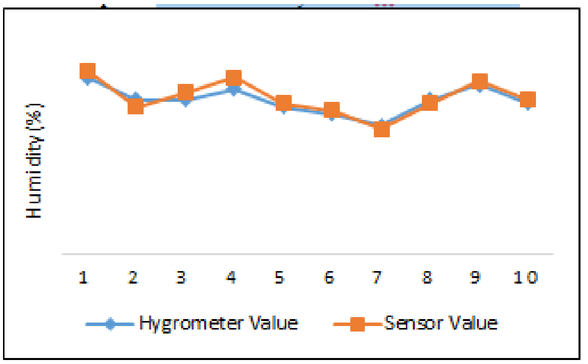


**Figure 8.** Actual humidity value vs sensor value

### 6. Relationship

We have established the relationship between ambient temperature and body temperature recorded by the prototype and also between ambient humidity and oxygen saturation of the body.

**Table 7.** Ambient temperature and body temperature

| S. No. | Ambient Temperature (ºC) | Body Temperature (ºC) | Difference (ºC) |
|---|---|---|---|
| 1 | 33.8 | 35.6 | 1.8 |
| 2 | 35 | 36.3 | 1.3 |
| 3 | 34.2 | 37.8 | 3.6 |
| 4 | 38.6 | 34.6 | 4 |
| 5 | 33.3 | 36.4 | 3.1 |
| 6 | 33.7 | 36.9 | 3.2 |
| 7 | 34.3 | 35.8 | 1.5 |
| 8 | 40.3 | 37 | 3.3 |
| 9 | 38 | 35.8 | 2.2 |
| 10 | 34.5 | 36.8 | 2.3 |

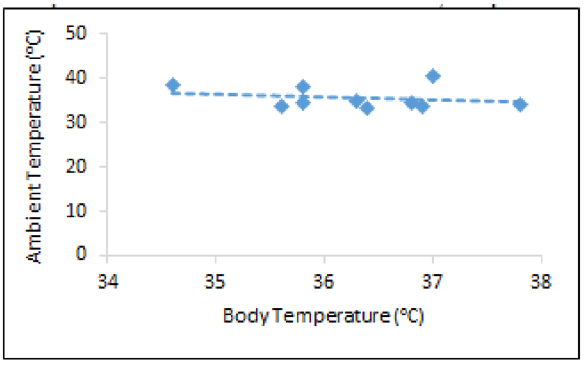


**Figure 9.** Relation between ambient and body temperature

**Table 8.** Ambient humidity and oxygen saturation

| S. No. | Ambient Humidity (%) | Oxygen Value (%) |
|---|---|---|
| 1 | 50 | 95.5 |
| 2 | 40 | 97 |
| 3 | 44 | 97.5 |
| 4 | 48 | 96.5 |
| 5 | 41 | 96 |
| 6 | 39 | 97.5 |
| 7 | 34 | 99 |
| 8 | 41 | 96.5 |
| 9 | 47 | 96.5 |
| 10 | 42 | 96.5 |

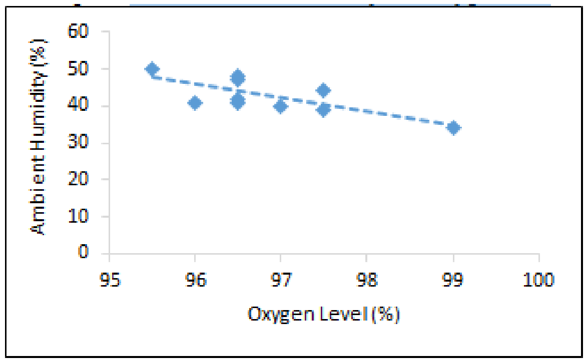


**Figure 10.** Relation between humidity and oxygen level

**7. Error Analysis**

We have computed the error (%) value for the measurement of parameters such as temperature, humidity, oxygen level and heart rate.

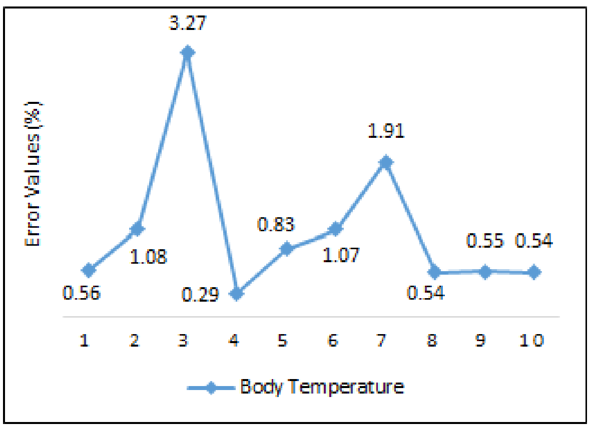


**Figure 11.** Error calculation in body temperature values

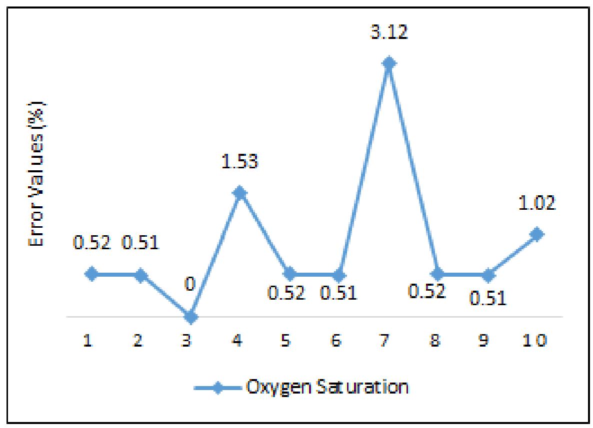


**Figure 12.** Error calculation in oxygen level values

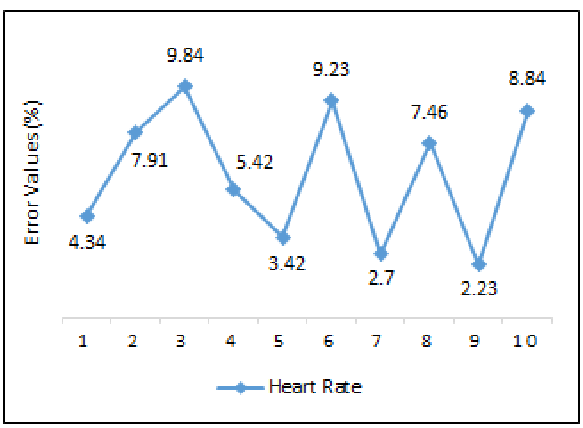


**Figure 13.** Error calculation in heart rate values

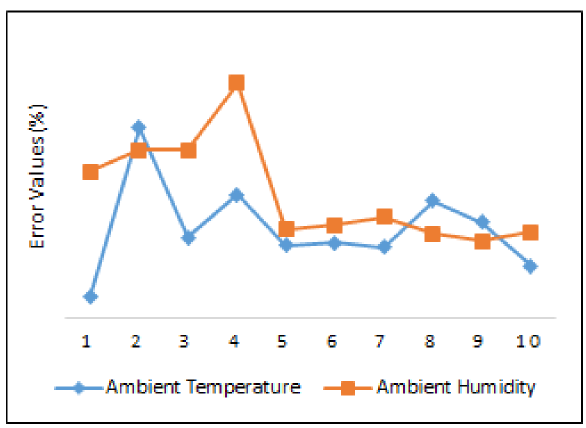


**Figure 14.** Error calculation in temperature and humidity

The experiments conducted during the course of this project have demonstrated that this system has an accuracy rate of more than 90%. This is a significant achievement and a testament to the effectiveness of advanced technologies.

## 8. Conclusion

The health monitoring system is an innovative project aimed at developing a comprehensive solution for continuous health regulating, leveraging advanced technology and data analytics. The system is designed to collect, analyze, and interpret health-related data from various sources, such as sensors, and electronic health records (EHRs), to provide real-time insights into an individual's health status. The project focuses on creating a user-friendly, scalable, and secure health monitoring system that can be used in various settings, including hospitals, clinics, homes, and remote locations. The system integrates mutiple data sources, including physiological parameters such as heart rate, oxygen saturation, body temperature, ambient temperature and humidity, and ECG value, as well as patient-reported data on symptoms, medication adherence, and lifestyle factors. The collected data is securely collected and processed, which facilitates remote monitoring and real-time data analysis.Based on the data analysis, it offers tailored feedback and suggestions to patients, carers, and healthcare professionals. Additionally, it offers timely warnings and notifications for crucial health events including aberrant vital signs, inconsistent prescription use, or significant health concerns. Through early identification and intervention, the system intends to enable people to actively control their health, enhance healthcare outcomes, and save healthcare costs. This is created to give people information on their current state of health, encourage healthy habits, and facilitate the early identification of future health issues. They can be a vital tool for individuals, healthcare professionals, and carers in achieving improved health outcomes. Their usesrange from basic wellness tracking to treating chronic illnesses.

## 9. Future Aspects

This project offers many futuristic scopes and its upgradations:

- Several sensors may be added to this prototype so as to increase the functionality and ability to recognize impediments.
- It is anticipated to grow much more in the future as cutting-edge technology like wearables and mobile apps.
- The system may be equipped with cameras to watch for geriatric patients to get real-time information. The camera also detects falls, which alerts carers or emergency personnel.
- Modern technologies such as IoT and AI may be employed to provide a wide communication range and more insights. AI can improve the accuracy of health monitoring systems and predict health issues before they occur.
- By examining the specifications and outcomes of the medical histories of many people, data mining is used to search for recurrent patterns and logical links in the condition.
- A sensor that determines the necessary amount of information regarding blood can be combined.

Based on the design and functionality of the prototype, it is feasible to develop it into a finished product. However, further testing is to be done to ensure its efficacy and sensitivity in the healthcare industry.

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