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A Review on IoT-Based Health Monitoring System for Real-Time Detection of Oxygen Saturation and BPM Anomalies and Body Temperature and Humidity

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ABSTRACT

Progressive fast-moving IoT technology has created smart health monitoring systems that revolutionize the way we care for patients and manage one's health today. This paper shows the IoT- based health monitoring system designed for continuous detection of real-time vital signs such as oxygen saturation (SpO2), heart rate (BPM), body temperature, and environmental humidity mainly to detect anomalies and alert users or care providers. The system uses sensors connected to small computers for continuous monitoring of health signs. A pulse oximeter sensor measures oxygen saturation and heart rate, while a temperature sensor captures body temperature. An additional humidity sensor is incorporated to monitor environmental ambient conditions that may be adversely affecting the health status of the patient. The system is a central online platform where the collected data is sent using IoT technology for processing and immediate analysis. Hence, this would be making it easy and much more effective for everyone in health monitoring, especially on severe conditions such as heart disease.

Keywords: IoT Device, SpO2, Heart Rate, MAX30100, monitoring device.

1. INTRODUCTION

Monitoring Human Health

1.Health monitoring implies an ongoing evaluation of parameters such as the heart, body temperature, blood oxygen saturation, and others that form the basis of important health variables in an individual's life. Continuous experimentation of these metrics allows one to realize early warning signs and offers considerable prevention that is otherwise difficult to realize. Health parameter monitoring is crucial when chronic conditions exist and on any acute transfer of health. Much has changed through technology as using wearable devices and IoT-based systems revolutionizes how we monitor health more effectively and efficiently.

Monitoring the Body Temperature

Body temperature will tell whether there is a disease, infection, or fever if there is clearly an evident difference from the baseline range. With regular monitoring of body temperature, an individual can easily be aware of the earliest indications of an illness. An early detection of fever can trigger intervention and prevent a possible complication. By employing the latest wearable health technologies and tools, self-monitoring becomes even more simplified when an individual wants to keep track of optimal body temperature on the way to better health management.1.3 Management of Chronic Conditions through Monitoring

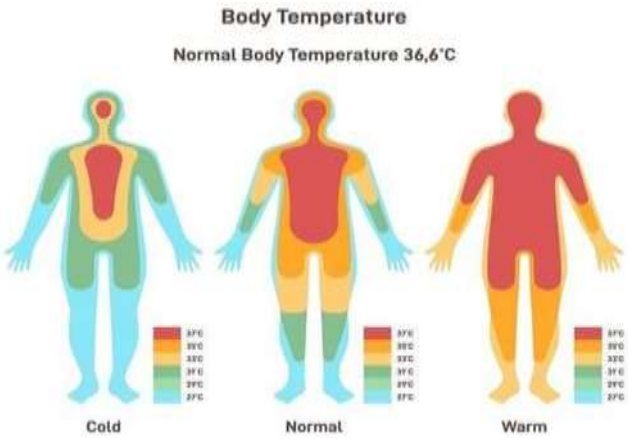

Fig: Body Temperature

Management of Chronic Conditions

Individuals who live with chronic diseases such as diabetes, heart problems, or respiratory disorders have to sustain their health monitoring activities on a regular basis for these particular chronic diseases require much vigilance in order to continue symptom management and to thwart complications, as exams show. The continuous monitoring of vital signs such as heart rate, blood sugar levels, and oxygen saturation keeps one in check with his or her conditions. Putting awareness of any abnormal readings early on can trigger actions such as medication changes and doctor appointments, which, in turn, will improve quality of life for people who live with chronic health conditions.

Monitoring health on an ongoing basis is important for individuals with chronic conditions such as diabetes, heart problems, and respiratory diseases. These conditions generally need to be watched closely for symptoms and complications. Keeping track of vital signs, such as heart rate, blood sugar, and oxygen saturation levels, enables better control over these conditions. Early detection of an abnormal reading can initiate immediate actions, such as medication modification or seeking medical attention, thus enhancing the quality of living among people suffering from chronic healthcare problems.

Average heart rates by age

Age in years	Average maximum heart rate in beats per minute	Target heart rate range in beats per minute
40	180	90 to 153
45	175	88 to 149
50	170	85 to 145
55	165	83 to 140
60	160	80 to 136
65	155	78 to 132
70	150	75 to 128

Source: American Heart Association.

Fig: Average Heart Rates by Age Prevention Health: Monitoring Promotions

Preventive health is that it motivates individuals to proactively take care of their well-being; this is a great area for preventive health improvement with respect to both diseases and conditions. In realistic terms, it will aid in health monitoring as major preventive involvement focused on the lift-off part in starting the healthy lifestyle habits monitoring: like, for example, when monitoring nudges a person to a diet or training behavior change when figures are sent to the instant communications following ones own monitoring devices. It, therefore, gives the possibility to mobilize in time to be able to give preventive interventions concerning chronic illnesses and optimal health outcomes.

Development of Technology in Health Monitoring

Technology has really been a miracle when it comes to providing monitoring and applications-slides that simply look promisingly effective-integration-into-health. Because for all practical purposes, these devices are worn on the outside of the body: smartwatches, fitness bands, and now even sensor bits to monitor vital signs continuously. Methods that could be put to use include not just immediate real-time feedback but also the opportunity to learn from individual-from-individual trends in health monitoring over a time scale. The updated telehealth solutions and the end-user IoT-delivered health solutions

add value to the health services and systems through remote monitoring-enabled health and greater efficiency of patient caretakers. 1.6 Positioning the IoT in Healthcare: Theory of Change Monitoring in Health

Evolves like all things: carpings, the Internet of Things goes-all-in-all health and health care. An empowered health monitoring system with a continuous capability to analyze vital health parameters such as oxygen saturation, heart rate, temperature and humidity can CARE FOR PATIENT patients from the hospital and can be implemented much sooner in the intervention process. All these improve, in fact, the quality of health services.

Blogs on Future Directions of IoT Healthcare Much is coming in the future for IoT in the health market, evolving from artificial intelligence (AI) to the excellence in wearables that are being developed. Not

least of these will be the importance accorded to detail accuracy in health matters, predictive analytics, and personal care. These telehealth services will top up other existing telehealth services, and with a robust smart health system, IoT will continually improve health outcomes using real-time continuous monitoring of health, which in turn allows prompt medical reactions.

Cores of Health Monitoring Systems based on IoT

An IoT-based health monitoring comprises of well-connected devices at ease that always watch on and transmit data about health. Such important components include wearable sensors that measure vital signs like oxygen levels in the body, heart rate, and body temperature. The data measured by sensors is sent to microcontrollers for processing, connections modules for transmission, and finally stored in cloud platforms for analysis. Patients and health providers will keep track of what happens with their health conditions in real time, allowing timely interventions when necessary.

Real-Time Health Monitoring Pros of IoT Health Systems Real-time health monitoring from IoT- enabled devices extends a lot of benefits to the patient and the healthcare provider. Detection of an anomaly within the health parameters such as heart rate, body temperature, and oxygen saturation would trigger fast medical action that would prevent health crises. Furthermore, the continual availability of health data encourages patient involvement as it shows more insight into their condition. That strengthens communication with providers and ushers the patient into a more customized, proactive approach to care.

2. LITERATURE SURVEY

This real-time project emphasizes the need for pulse oximeter instruments established by high- sensitivity pulse oximeter and heart-rate sensor MAX30100 with NodeMCU for continuous health monitoring. The device is also competitive in price, convenient, and lightweight, and can be strapped around the wrist. Therefore, it makes it easier and more comfortable for users.

As such, heart rate and SpO2 sensor readings will be transferred in real-time to a PDA like smartphone, tablet, etc. Internet of Things (IoT) technology, hence, the ability of users, caregivers, as well as healthcare providers to monitor health conditions of old or home patients makes things much easier and adds peace of mind.

The system also has a section for logging into the application. This means that only those users with authorized rights, family members, caregivers, or medical personnel, will have access to health data through this system, thus ensuring privacy and safety of user information, which is crucial for building trust with both users and healthcare professionals.

3. METHODOLOGY

Development of SpO2 and Heart Rate Monitoring IoT

System Design and Hardware Developments:

- Using MAX30100 sensor, we have developed a system for measuring SpO2 levels and heart rate.

The data was sent to the NodeMCU ESP8266, which is nothing more than a small computer, transmitting data via Wi-Fi.

Data Storage and User Interface:

- Collated Data (Heart Rate and SpO2 levels) will be stored Online in Cloud Database (Firebase).
- To keep simple monitoring for Users (Like Old Age Users and their Family and Medical Avails) in Real-Time. The system sends notifications if something goes bad with the measurement.

Collection and validation of data

1. Data acquisition:

- The sensor records light reflected from blood vessels (PPG signals). It was tested on five healthy subjects for a continuous measurement of 30 seconds.

2. Data Segregation and Processing:

- Next, the raw data are sliced into portions easy to operate with. We computed the SpO2 level and heartbeats through the signals.

3. Comparison With Commercial Oximeters:

- Results were then compared with those achieved on a conventional commercial pulse oximeter for accuracy checks with the proposed system.

Saturation Measurement and Classification of Healthy and Unhealthy States

1. SpO2 Classification:

- Normal SpO2 levels are 95% and above; under 95% is considered malfunctioning (low oxygen levels).

2. Heart Rate Classification:

- Nor- Heart rate between 60 and 99 BPM (beats per minute). Above 99 or below 60 is considered non-normal.

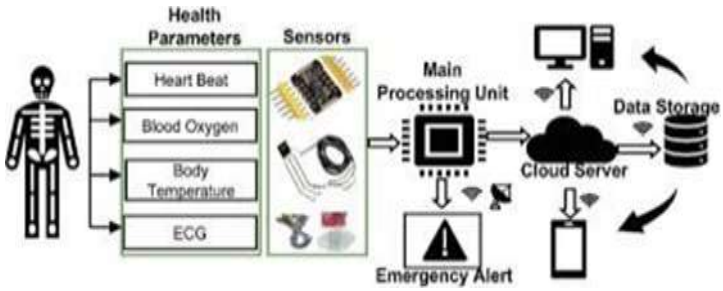

FIG: IOT BASED SMART HEALTH MONITORING SYSTEM

MAX30100 Pulse Oximeter

- The MAX30100 sensor is an example of red, and IR lights shine through the skin and measure the absorbed light by blood, and this helps calculating the oxygen level and heart rate.

NODEMCU

- NodeMCU is the very small device in-built with Wi-Fi which sends data from the sensors to the cloud and makes the system connected to the internet for remote monitoring.

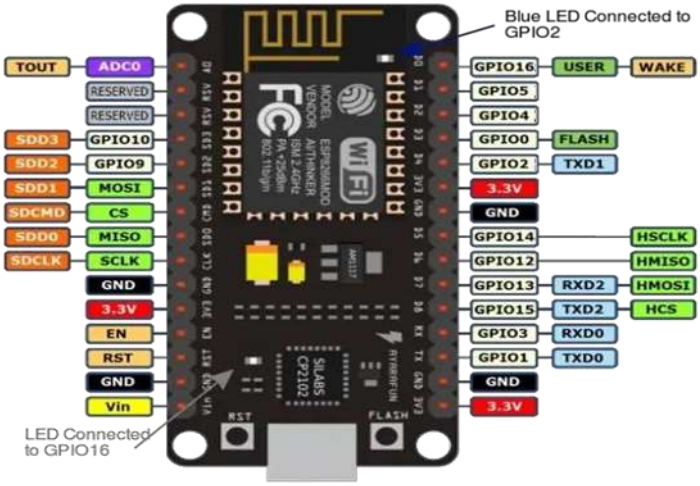

FIG: NODEMCU PIN DIAGRAM

Pulse Sensor

- Pulse sensor works by illuminating the skin and measuring alterations in blood flow caused by the heart beat and converts it into digital data computed into beats per minute.

Blynk App

- Blynk is a way to keep track of your IoT devices on your smartphones. Allows real time data, alerts when anything fails and keep tabs on health metrics from a distance.

Temperature and Humidity Sensors in Health Monitoring Systems

1. Concept of Temperature and Humidity:

- Temperature is important to health monitoring. High fever or a low temperature may be indications of an ill body.
- Humidity is just as important. Too high humidity leads to respiratory problems; too little humidity causes dryness of skin and other health complications.

Types of Temperature and Humidity Sensors:

- Thermistors and RTDs are temperature sensors. They are very accurate and helpful for monitoring body temperature in health systems.
- Humidity sensors measure the moisture present in the air and help keep track of the climatic conditions within a vicinity like hospitals.

4. RESULTS AND DISCUSSIONS

4.1 The Practical Application of MAX30100

In our deep dive into MAX30100 sensor and the best possible, most reliable data that this sensor could yield, here are some key points that needed to be observed:

- All components must be properly soldered to avoid using breadboards.
- Properly connect the MAX30100 to the Arduino ESP8266 according to the instructions.
- Measurements have to be taken on the middle finger of the right hand; others suggest it can also be done on the fingertip.
- Keep finger still and closed while taking measurements.
- It is good to take three readings for improved accuracy.

4.2 Results of SpO2

SpO2 or blood oxygen level is determined using infrared (IR) and red light, and after processing the data, SpO2 values ranged from all above 96%. This means they are normal and healthy oxygen levels. This was expected since the subjects tested were healthy people.

TABLE1: SPO2 RESULTS BASED ON A DATASET 1 OF IR/RED

No of segment	Ratio	SpO2 (%)
1	0.53	96.82
2	0.51	97.23
3	0.55	96.20
4	0.52	97.11
5	0.55	96.27

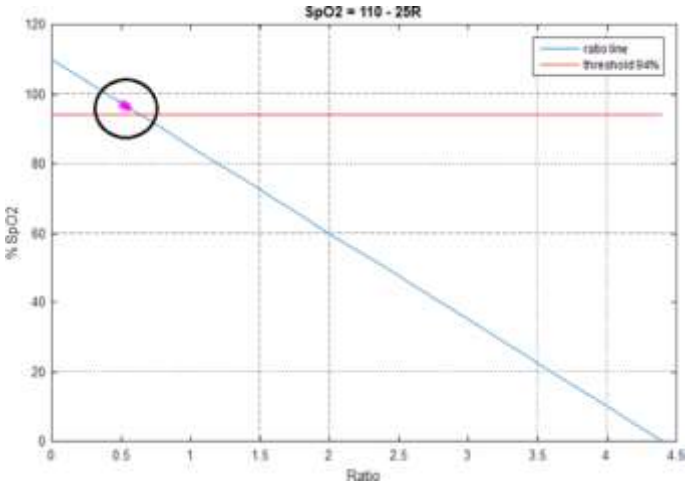

FIG: The SpO2 against ratio results for a dataset 1

Results of Classification

The SpO2 and heart rate of the patients are classified using rules that state the following:

- 100 sets of data were used to test the system (50 normal and 50 abnormal).
- For SpO2, the system gave 100% and 96% accuracies for normal and abnormal readings respectively.
- Heart rate classification was perfect (100 percent accurate) for normal and abnormal conditions as well.
- Combining SpO2 and heart rate, the system achieved 100% accuracy for normal cases, while for the abnormality cases, it managed to get 98%. The slight error in the abnormal case is attributed to the misclassification of SpO2.

4.3 Comparison with a Commercial Oximeter

Heart rate data readings taken through the MAX30100 sensor were compared with that taken through a commercial oximeter. The analysis indicated a very strong positive correlation (rs > 0.8). This indicates that the values in the readings collected through the MAX30100 were very close to that of the commercial oximeter. The results were statistically significant and confirmed the accuracy of the MAX30100 sensor.

4.4 Comparison with a Commercial Oximeter

We also analyzed the performance of the MAX30100 system against a commercial oximeter for five different subjects. Errors in readings were found to be below 3%, which is an acceptable range and indicates good functioning of the system.

4.5 Real-Time Performance through IoT

This computes the heart rate and SpO2 data transmitted by the system to an internet-based database (firebase) along with displaying it on a secure webpage. Data access is only made available to persons who are authorized- patients, close family members, and doctors. This is designed to protect the system from fraudulent logins, and therefore the storage of information is safe. It is therefore suitable for real- time health monitoring, especially for the elderly, where continuous monitoring is essential.

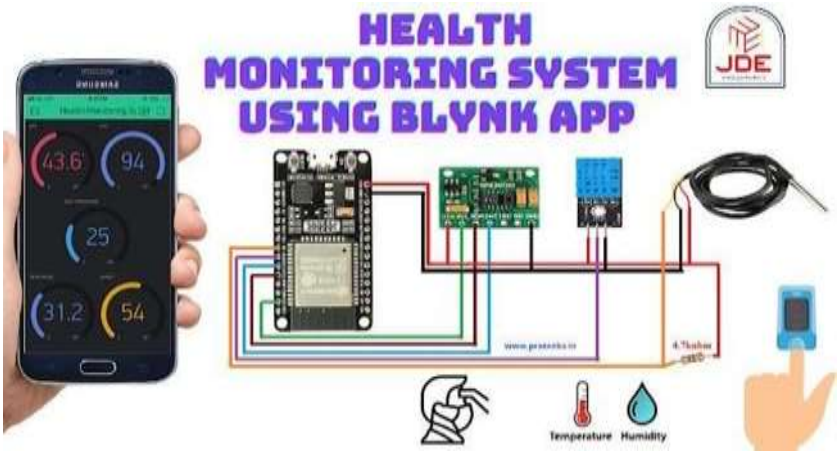

FIG: health monitoring system using blynk app

TABLE2:

Name	**Heart Rate**	**Oxygen level %**	**Body temperature**	**Humidity**
Patient 1	62	70%	30^0C	61
Patient 2	60	70%	23.6^0C	71
Patient 3	84	90%	25.2^0C	54
Patient 4	82	89%	33.5^0C	39

5. CONCLUSION

Few of the most probable good proof applications includes the one technology that uses IoT. The health monitoring system being developed using IOT is basically done for real-time monitoring of oxygen saturation (SpO2), heart rate (BPM) and body temperature, humidity. This sort of real-time data processing significantly contributes to personal health care. Sensors are networking with wireless technologies such that an individual can continuously

remotely monitor any vital parameter. Such a system is useful in the timely early detection of possible anomalies related to the vital signs. That real- time data can be sent to a healthcare provider or caregiver for early intervention to block further advancement and hence avoid fatality or complication of health. In addition, tracking multiple parameters gives a comprehensive view of a patient's health status thus improving the overall quality of care provided.

BODY and H units with an ability to research about the environmental parameter and other temperature sensors using the body together with monitoring of parameters affecting health may have been added to facilitate the monitoring process for vulnerable people such as the elderly and patients suffering from respiratory conditions. IoT promotes the improved accuracy of health assessments but at the same time makes healthcare more accessible for people in remote areas as certain forms of health monitoring may not be available in the vicinity. Data security would prove a challenge in addition to those that limit the development, such as power consumption and the future integration of the systems. Important advancements in sensor technology, connectivity, and data analytics in the future will only keep upgrading the reliability and efficiency of these systems in modern healthcare.

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