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IOT Based Real-Time Health Monitoring and Alerting System

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ABSTRACT: This paper presents the design and development of a smart health monitoring system that tracks user activity and provides meaningful insights. The system employs sophisticated sensing technologies to detect and track physical activity levels, and compute associated health metrics. Integration of communication technology to provide real-time alerts, making users more active and aware. The system is relatively simple and adjustable to different purposes in health and fitness tracking, emphasizing efficiency and speed. Future research can also look into the growing potential of technology-driven health monitoring to promote healthy lifestyles through seamless data collection and communication.

KEYWORDS: Smart Health Monitoring, Activity Tracking, Health Metrics, Real-Time Notifications, Communication Technology, User Engagement, Fitness Tracking, Data Collection

I. INTRODUCTION

The necessity of health monitoring has seen an exponential increase in recent fast-paced era. As lifestyle diseases are becoming more common and immediate medical care is required, technology has created an opportunity for brilliant healthcare innovations. Chronic disease or health care disease is becoming a major problem all over the world and going for outpatient treatment is stressful and can be very challenging for patients with chronic illness. Monitoring patients remotely using IoT has drastically changed the way we monitor patient vitals and respond in the case of an emergency.

The "IoT based Real Time Health Monitoring and Alerting System" works with the mission of monitoring important health parameters and sending quick alerts in case of any abnormality.

This system not only promotes preventive healthcare but also reduces the burden on healthcare facilities by enabling early intervention. With features such as data-driven insights and intelligent alerts, it represents a step toward smarter and more connected healthcare ecosystems.

II. LITERATURE REVIEW

1. Islam et al.,2015 [1] has proposed the expression "IoT" was inclusive and montage relations and constraints. The fusion of the Internet of Things (IoT) in health care has given rise to real-time health
2. monitoring systems improving patient care, allowing remote monitoring and timely detection of diseases.
3. A1-Fuqaha et al.,2015 [2] explained about the overall objective of IoT is to make sure the internet based communications, and sending and receiving data, become conventionally available along with "electronic sensor" devices. The primary goal of IoT is to automate healthcare systems, allowing messages to flow freely between them. The main goal of IoT is to connect automation with healthcare systems so it can deliver messages without putting in human intervention. Networked IoT sensors such as accelerometers and embedded microcontrollers are necessary components that facilitate automated data collection and transmission for analysis .
4. Li et al.,2020 [3] mentioned one of the greatest areas where IoT will be beneficial is the maintenance burden reduction and access to healthcare in remote areas.
5. Rahmani et al., 2018 [4] has proposed about IoT-enabled health monitoring systems rely on a system of interconnected sensors, microcontrollers, and cloud-powered platforms to acquire, process, and analyze patient health data. Advanced biomedical sensors like temperature sensors, heart rate monitors, and motion sensors are integrated into these wearables, allowing continuous monitoring of vital parameters .

6. Ahamed et al., 2020 [5] explained about these instruments communicate wirelessly to cloud servers or edge computing systems and enable remote monitoring of patients by health care professionals and caregivers .
7. Zhang et al., 2021 [6] discussed about solutions can therefore intervene in real-time, leading to decreased hospitalizations and better overall disease management. More so, recent reports emphasize the integration of machine learning and artificial intelligence (AI) algorithms into IoT healthcare applications, enabling better predictive analysis, anomaly detection, and personalized treatment recommendations .
8. Ting et al, 2020 [7] explained about though there are many benefits of IoT in healthcare, its implementation also poses challenges like security and data privacy as well as system interoperability. The IoT-based scenario shows that it is important for patient data collected through the IoT devices to be encrypted and also securely transmitted from the IoT devices to avoid cyber threats and unauthorized access.
9. Gubbi et al., 2013 [8] explained that it is also important to comply with healthcare regulatory frameworks like Health Insurance Portability and Accountability Act (HIPAA) and General Data Protection Regulation (GDPR) to ensure patient confidentiality. Power consumption and device reliability are also important factors, especially in the case of wearable and implantable IoT devices to maintain confidentiality for patients .
10. Hassanaliheragh et al., 2015 [9] explained that for wearable and implantable Internet of Things (IoT) devices, power consumption and device reliability are major challenges to be considered. The future of electronic health monitoring systems based on IoT will be more secure and efficient with developments in energy-efficient sensors, secure communication protocols, and blockchain-based healthcare data management.

III. SYSTEM METHODOLOGY

The system methodology involves the continuous monitoring of vital health parameters using IoT sensors, real-time data transmission, and instant alerting for abnormal conditions.

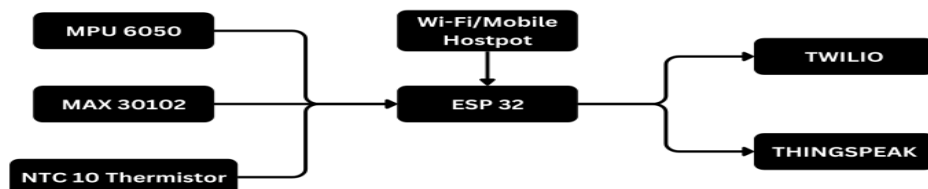


Fig 1. System Methodology

3.1 Existing Design (Or Original Design)

The initial step involves reviewing and analyzing existing health monitoring systems and alerting models available in the IoT landscape. This exploration includes studying wearable health trackers, smart home health systems, and cloud-based health monitoring solutions. The objective is to understand their architecture, sensor integration, communication protocols, and limitations to identify key design elements that can be improved or adapted for the development of an efficient, real-time IoT-based health monitoring and alerting system.

3.2 Generalization

The insights gained from existing health monitoring systems are abstracted to identify generalized components and communication frameworks. These generalized models include key elements such as sensor nodes for data collection, communication protocols for data transmission, and cloud or local systems for data processing and alert generation. The goal is to establish a flexible framework that can accommodate various sensor types and communication technologies, ensuring scalability and adaptability for diverse healthcare applications.

3.3 Number Synthesis

In this phase, the system architecture is synthesized by estimating the right number of sensors, communication module and processing units needed for health monitoring. While synthesis, the number of sensors to be used e.g., for heart rate, temperature and motion detection are chosen, and the communication of these sensors is defined based on communication nodes to ensure effective data transfer. To target this goal, we aim to develop a complete system for real-time data collection and processing with a trade-off between performance and resources.

3.4 Specialization

Heart rate monitors, temperature sensors, and motion detectors are chosen depending on their precision and compatibility. The data collected by these sensors is sent to the ThingSpeak cloud platform where it is stored and analyzed in real-time. At this point in time you can send signals over a more secure internet connection and formatted via HTTP request to ThingSpeak. "The cloud uses analytics and visualization to let users know important health estimates, alerts for anomalies and make better health decisions; these features make the health parameter machine-to-machine, i.e. the platform can tell the patient indirectly about their condition and take action accordingly."

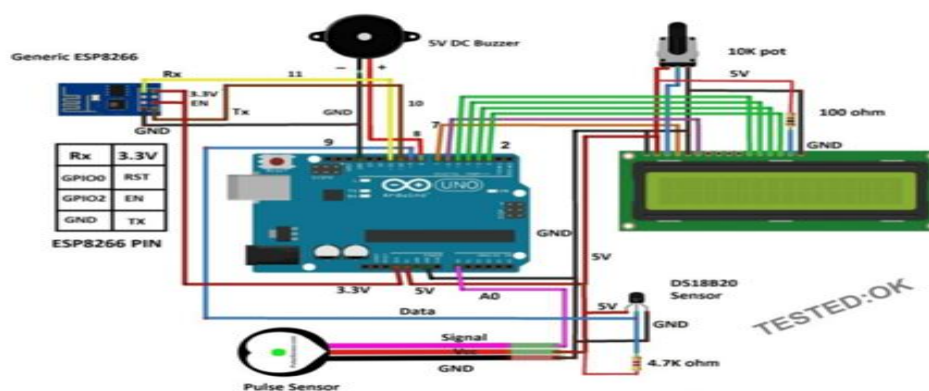
3.5 Particularization

Particularization involves converting the specialized design into a fully functional and integrated health monitoring system. The selected sensors, including heart rate monitors, temperature sensors, and motion detectors, are interfaced with a central processing unit, such as a microcontroller. The system is programmed to collect sensor data, process it, and transmit it to the ThingSpeak platform using secure HTTP requests. A user-friendly interface is established for real-time data visualization and monitoring through the ThingSpeak dashboard. Additionally, alert mechanisms are configured to notify users of abnormal health conditions, ensuring timely action and enhanced system effectiveness.

3.6 Atlas of New Designs

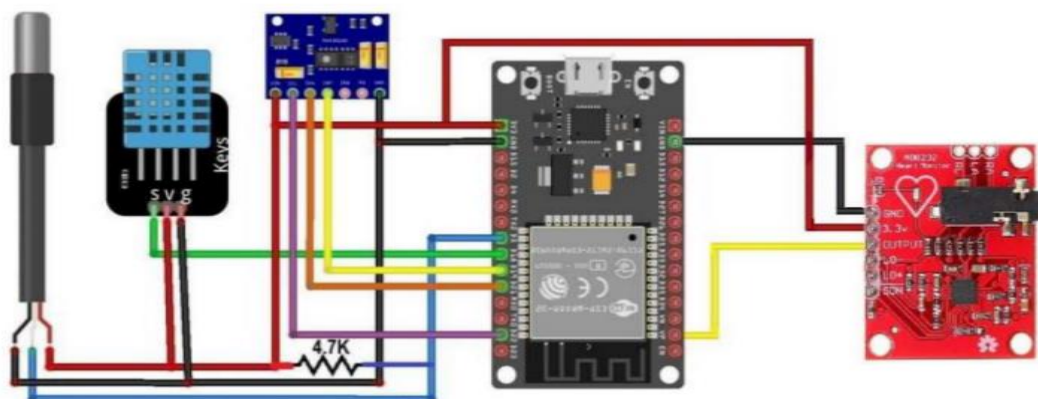
The final step involves documenting and evaluating all the variations and configurations derived from the specialized designs. Each configuration represents a potential implementation of the IoT-based Real-Time Health Monitoring and Alerting System with unique combinations of sensor types, data processing techniques, and communication mechanisms. The atlas of designs includes models with different sensor placements, power-efficient configurations, and optimized data transmission strategies to cater to various health monitoring applications. This comprehensive catalog provides a valuable reference for future system enhancements and adaptations to meet diverse healthcare requirements.

IV. EXISTING MECHANISMS



(a)Design 1

Fig2. The existing design



(b) Design 2

Fig 3. Few of the existing designs

In design 1, they have used an Arduino UNO board and generic ESP8266 along with the pulse sensor. This design continuously logs the pulse data of the person into a 16 x 2 LCD. It also has a buzzer which could create buzzing sounds when the threshold value meets as provided in the logic. In design 2, an ESP32 is used with a pulse sensor, DHT11, DS18B20 and an accelerometer sensor which just logs the data into the serial monitor. Some previous research studies related to IoT-based real-time health monitoring systems.

4.1 IoT in Healthcare: Enhancing Patient Monitoring

A study by Mukhopadhyay et al. (2015) shows how IoT-based wearable sensors can track vital health parameters like heart rate, body temperature, and ECG. The research showcase that real-time data collection via cloud computing improves patient care and reduces the burden on healthcare professionals.

4.2 Real-time Health Monitoring Using IoT and Cloud Computing

Rahman et al. (2018) developed a real-time health monitoring system integrating IoT and cloud platforms. The system provided remote monitoring capabilities for chronic disease patients, ensuring timely interventions through automated alerts.

4.3 Wearable Sensors for Continuous Health Monitoring

Research by Pantelopoulous & Bourbakis (2010) reviewed various wearable devices for real-time health tracking, highlighting advancements in sensor technology, data analytics, and communication protocols. The study emphasized the importance of low-power consumption in IoT healthcare applications.

4.4 IoT-Based Smart Healthcare System for Early Disease Detection

Gubbi et al. (2013) proposed a cloud-based IoT model for monitoring physiological parameters and predicting diseases based on historical data. Their work laid the foundation for AI-driven predictive healthcare solutions.

4.5 Smart Health Monitoring Using IoT and AI

A study by Baker et al. (2020) integrated artificial intelligence with IoT-based health monitoring, demonstrating improved accuracy in diagnosing cardiovascular conditions using real-time sensor data and machine learning algorithms.

V. TECHNOLOGIES USED IN IOT HEALTH MONITORING

The efficiency of IoT-based health monitoring systems depends on advanced sensing technologies, communication protocols, and cloud computing. **Previous studies analysed the fundamental components of** IoT healthcare architecture, **identifying** wireless sensor networks (WSNs), cloud platforms, and edge computing **as key enablers of**

real-time health monitoring. Their research established that low-power, high-efficiency sensors are essential for continuous health data acquisition.

Various wearable sensors include ECG, pulse oximeters (SpO2 sensors), accelerometers, and body temperature sensors, which play a critical role in modern IoT health monitoring applications. Largely covered the essence of these sensors along with their reliability and accuracy, while illustrating by how much multi-sensor integration enhances patient monitoring by enabling a more comprehensive analysis.

Data transmission and communication technologies are one of the most important parts of IoT-based healthcare. Protocols for Wireless Networks in Healthcare Applications, which focuses on Bluetooth Low Energy (BLE) for short-range connect to wearables, Wi-Fi and LoRaWAN can be used to send data to the cloud, and NB-IoT and LTE-M for remote patient monitoring over long distances. They found that the communication technology that is the most efficient in terms of data bandwidth, energy, and network coverage is normally selected.

Central to the functionality of the cloud is the processing and storage of health data. Is Large Scale Research: research on the cloud highlighted that AWS, Google Cloud and Microsoft Azure platforms streamline health data management, enabling secure and scalable healthcare applications. At the same time, the use of edge computing as a low-latency method of processing health data on IoT devices has also gained popularity.

Another important point is the use of encryption and authentication mechanisms (TLS, SSL), and blockchain to protect sensitive medical data. The study highlights that secure communication channels and encrypted data storage will be vital for extensive use of IoT in healthcare.

VI. PROPOSED SYSTEM: IOT-BASED REAL-TIME HEALTH MONITORING AND ALERTING SYSTEM

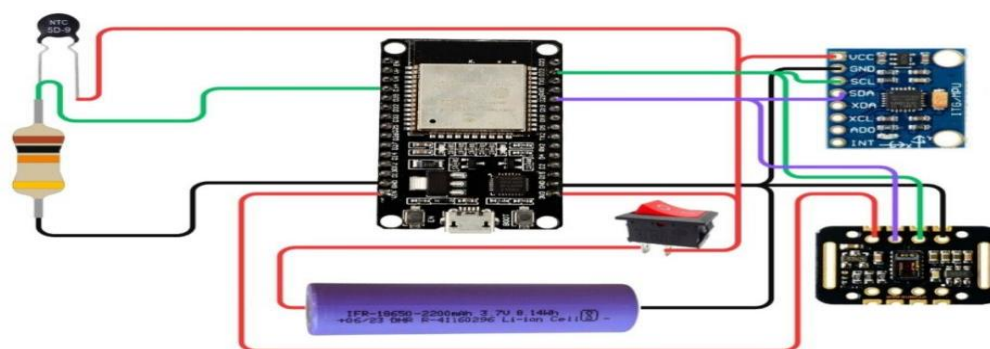


Fig. 4 Proposed Design

6.1. Design Requirements

- (1) ESP32.
- (2) MPU6050.
- (3) MAX30102.
- (4) NTC 10K Thermistor.
- (5) 10K Resistor.
- (6) 18650 Battery Cell.
- (7) Switch.

6.2. Design Constraints

- (1) Limited Battery Capacity.
- (2) Needs Internet Connectivity via Wi-Fi/Hotspot.
- (3) Covers whole palm, knuckles and wrist of hand of the user.
- (4) Has limited SMS per day.

6.3 Overview of the System

The IoT-Based Real-Time Health Monitoring and Alerting System continuously monitors and analyses a user's crucial health parameters and displays the results in real-time while providing alerts to ensure timely healthcare intervention. This framework combines cutting-edge sensing devices, cloud-enabled data processing, and communication protocols for the continuous monitoring of physiological parameters like heart rate, temperature, and motion activity.

6.4 System Functionality

The main aim is to collect and transmit real-time physiological data like body temperature, heart rate, blood oxygen, and motion with the help of the IoT-based Health Monitoring System. The combined components of IMU and HeartBeat trackers help in continuous monitoring of health parameters and transmitting them to cloud services using IoT communication. The system architecture can be segmented into various layers data acquisition, data transmission, data processing, data storage, and data visualization.

6.4.1 Health Data Acquisition

This starts with the collection of physiological data through sensors attached to IoT instruments. This system uses these primary sensors:

NTC 10K Thermistor: This is a temperature sensor to measure body temperature. It measures temperature via changing resistance of the thermistor, which is excellent for monitoring the fever or any abnormal condition of the body temperature.

MPU 6050: A 6-axis accelerometer and gyroscope sensor that detects physical movement and orientation. It tracks patient movement and can detect falls, an important capability in health monitoring for older or at-risk patients.

MAX 30102: This sensor measures and provides pulse rate and oxygen levels; it is essential for monitoring health promptly.

6.4.2 Data Transmission

Health data is either collected by a datastore over the network or sent to the cloud, where it can be stored and further processed. In addition, it makes use of the MQTT protocol, which allows to transmit data very efficiently, with low bandwidth, and allows real-time update of the data.

MQTT Protocol: This protocol is utilized to send the sensor data measured by an IoT device to the cloud service, which allows rapid communication with minimal latency. The MQTT broker (e.g., running on a local server or cloud) provides the real-time flow of data, which is critical for health monitoring systems.

6.4.3 Cloud Data Storage and Processing

The health data collected by the sensors is uploaded to **ThingSpeak**, a cloud platform designed for IoT data storage and visualization. ThingSpeak provides real-time analytics, allowing users to visualize sensor data through graphs and dashboards.

ThingSpeak: ThingSpeak is actually an IoT analytics platform which can be used to store time-series data. It also offers powerful data analysis tools. The platform allows real-time monitoring of parameters like temperature, heart rate, and SpO2, making it a suitable choice for continuous health monitoring systems.

6.4.4 Alerting and Communication

To ensure the patient's health is monitored actively, the system sends alerts if any parameter goes beyond predefined thresholds, such as abnormal temperature or heart rate levels. These alerts are crucial for taking immediate actions, such as seeking medical attention.

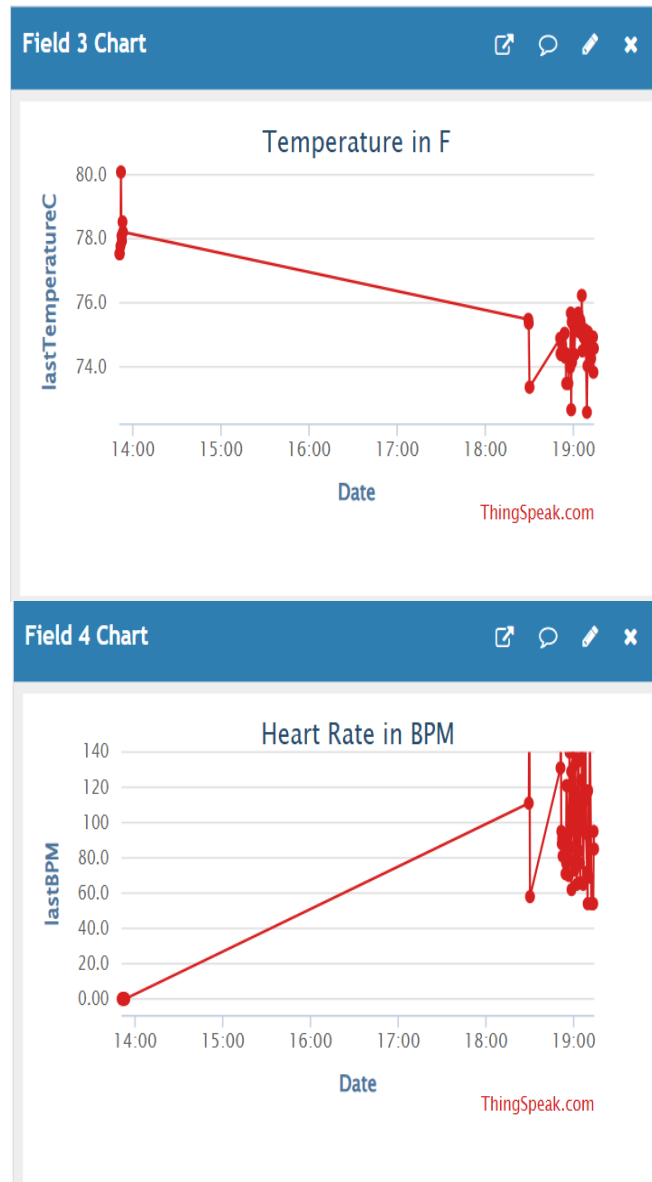
Twilio API: Twilio is used to send SMS or email alerts to caregivers, family members, or healthcare providers. If any parameter exceeds safe limits, the system can trigger automated notifications, ensuring timely interventions.

6.4.5 Real-Time Visualisation

The health data is visualized on dashboards built using ThingSpeak, where users can monitor their health statistics over time. The platform displays real-time graphs for each monitored parameter (temperature, heart rate, SpO2) and allows for historical data analysis.

Here are some Real-Time Graphs





ThingSpeak Visualisation: ThingSpeak's integrated visualization tools provide graphs and plots to track patient health in real-time, allowing healthcare providers to easily review trends and identify any anomalies.

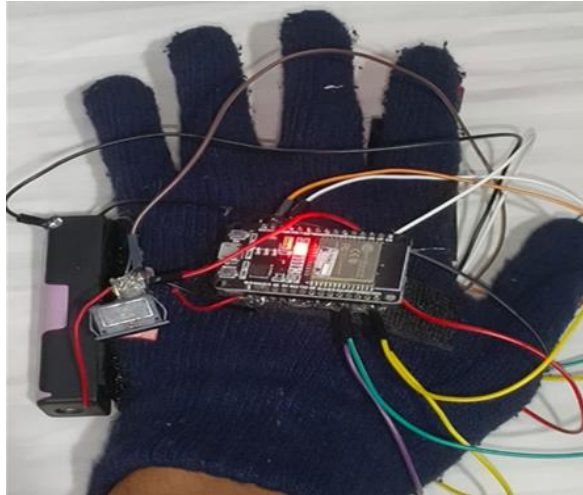


Fig 5. Front View of Prototype



Fig 6. Rear View of Prototype

VII. CONCLUSION

An IoT-based Health Monitoring and Alerting System has been developed in this study as a robust, efficient solution that enables continuous and real-time parameter monitoring like body temperature, heart rate, and blood oxygen level among other critical health parameters. The system enables accurate data acquisition and transmission for real-time health surveillance by leveraging widely used and reliable sensors such as NTC 10K Thermistor, MPU 6050, MAX 30102 respectively. Integration with cloud platforms such as ThingSpeak enables effective storage and visualization of data, as well as analysis for remote monitoring of patient health by health providers and care givers.

Utilizing MQTT for secure and low latency data transfer combined with Twilio for timely notifications allows for an effective response to abnormal readings by providing real-time data and notifications for timely intervention. Additionally, the modular structure and extensibility of this system render it broadly applicable to numerous use cases — from single-person health monitoring through to national level remote monitoring and patient care. With continuous monitoring, reduced load on health facilities, and improved health care delivery, the benefits of IoT technologies prevail in healthcare sector. However, challenges such as data security, privacy, and integration with existing healthcare infrastructures need to be addressed in future work. With ongoing advancements in IoT, cloud computing, and sensor technologies, the proposed health monitoring system has the potential to become a cornerstone of personalized healthcare, offering a practical solution for improving health outcomes and enhancing the quality of life for patients, particularly in remote areas.

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