

Smart Health Monitoring with IoT and Biomedical Sensors for Continuous Patient Care

C. Abdul Rahman^{1*}, Mohamed Yousuff Caffiyar², M.K. Sudeva Bharathi³,
P. Santosh³, C. Suriya³, B. Reshi Kesavan³, N. Varun Kumar³

Abstract

Smart Healthcare is important for people who need continuous monitoring which cannot be provided outside hospitals. It is also important in rural areas or villages where nearby clinics can be in touch with city hospitals about their patient's health conditions. This work presents a smart health monitoring system that uses biomedical sensors to check a patient's condition and uses the internet to inform the concerned. The biomedical sensors here are connected to an ESP32 controller to read the data which is in turn interfaced to an LCD/serial monitor to see the output. An android application has been designed to easily see the patient's information by their doctors and family. Smart Healthcare is important for people who need continuous monitoring which cannot be provided outside hospitals. It is also important in rural areas or villages where nearby clinics can be in touch with city hospitals about their patient's health conditions. This work presents a smart health monitoring system that uses biomedical sensors to check a patient's condition and uses the internet to inform the concerned. The biomedical sensors here are connected to an Arduino UNO controller to read the data which is in turn interfaced to an LCD/serial monitor to see the output. Data is uploaded to the server to store and converted into Javascript Object Notion (JSON) links for visualizing it on a Smartphone. An android application has been designed to easily see the patient's information by their doctors and family members.

Keywords: Health monitoring, wearable devices, remote patient monitoring, telemedicine, healthcare technology

*Author for Correspondence

C. Abdul Rahman
E mail: cabdulrahman.ece@cahcet.edu.in

¹Assistant Professor, Department of Electronics and Communication Engineering, C. Abdul Hakeem College of Engineering and Technology, Melvisharam, Tamil Nadu, India

²Associate Professor, Department of Electronics and Communication Engineering, C. Abdul Hakeem College of Engineering and Technology, Melvisharam, Tamil Nadu, India

³Student, Department of Electronics and Communication Engineering, C. Abdul Hakeem College of Engineering and Technology, Melvisharam, Tamil Nadu, India

Received Date: September 16, 2024

Accepted Date: October 01, 2024

Published Date: October 25, 2024

Citation: C. Abdul Rahman, Mohamed Yousuff Caffiyar, M.K. Sudeva Bharathi, P. Santosh, C. Suriya, B. Reshi Kesavan, N. Varun Kumar. Smart Health Monitoring with IoT and Biomedical Sensors for Continuous Patient Care. Journal of Microcontroller Engineering and Applications. 2024; 11(3): 1–8p.

INTRODUCTION

Health is not merely the absence of disease but should be understood as a state of complete physical, mental, and social well-being. People's aspirations for a better life are based on their health. Unfortunately, several issues related to the global health crisis, including inadequate health services, significant disparities between rural and urban areas, and shortages of doctors and nurses in times of crisis, have created a predicament. The Internet of Things (IoT) has been seen as the next big technological revolution in the past decade, as it begins to connect all things internally. IoT applications include smart health monitoring systems, smart parking, smart homes, smart cities, smart weather, industrial sites, and agricultural sectors. The most amazing app. In the field of medicine, there are many fatal diseases, such as heart disease, diabetes, breast cancer, and liver

damage; however, the main concern of the system developed by our company is to understand the early symptoms of various types of patients and the patient's environment regarding monitoring. This paper describes a custom medical care system that uses sensors to monitor pulse and body temperature, indoor humidity, and CO and CO₂ levels in a hospital room, transmitting these data via Wi-Fi to the medical staff. Allows data recovery. Suggesting a system from the server.

In addition to recording a variety of health metrics, such as body temperature, heart rate, photoplethysmograph (PPG) signal, caloric intake, smart activity monitoring, and stress measurement, the majority of modern smartphones also enable the user to be monitored by a family doctor via GSM or even the IoT. The wearable IoT-cloud-based health monitoring system (WISE), one of the newest and most advanced real-time personal health monitoring systems, is a combination of a body area sensor network (BASN) and an IoT framework for ubiquitous health monitoring. Beyond the IoT and BASN, wearable health monitoring technologies will have a bright future.

LITERATURE REVIEW

The increased interest in improving patient care through real-time data collection and analysis is highlighted by the literature on smart healthcare monitoring systems, particularly those using IoT technologies, such as ESP32. Previous studies have examined several IoT-based healthcare systems, emphasizing their potential for proactive healthcare interventions, illness management, and remote patient monitoring. Numerous platforms and microcontrollers have been investigated for their suitability for building such systems; However, ESP32 has become a widely used option owing to their low power consumption, integrated connectivity features, and large processing capacity. The researchers also examined several sensor technologies and showed that it is possible to integrate these sensors with an ESP32-based platform to measure essential health metrics, including blood pressure, body temperature, and heart rate. In addition, ESP32 repeatedly shows positive results in terms of reliability, adaptability, and ease of integration in comparative evaluations of the performance, scalability, and cost-effectiveness of IoT systems in healthcare applications.

Kher and Patel provided a thorough analysis of the wearable medical monitoring devices suggested by the researchers [1]. Since the IoT has expanded significantly in healthcare systems, including fitness programs and health monitoring, Selvaraj and Sundaravaradhan examined the most recent research articles that dealt with IoT-based healthcare systems. To increase the effectiveness of monitoring, considerable research has been conducted on IoT-based healthcare systems [2]. Along with recent developments in smart health monitoring (SHM) and current issues, Sujith et al. conducted a systematic review of SHM [3].

Attempts to monitor health using pertinent features and sensors, such as MAX30102, which emits light to sense a person's blood concentration and subsequently shows their air pressure, are not new. It evaluates the patient's vitals and provides relevant parties with information via the internet. Because of its compact size, it is portable and can be used anywhere [4]. Manjupriya et al. created a basic module utilizing ESP8266 to check health. All parameters were monitored by an ESP8266, and a mobile device attention monitoring system was designed to offer regular online data regarding a patient's physiological parameters. It is primarily composed of sensors and an information-gathering device. The Arduino program was programmed using this code. The patient's blood pressure, temperature, heart rate, and graph knowledge will be tracked, shown, and stored by the system. Additionally, it transmits this data to the mobile device of the doctor and the patient [5].

Kola et al. presented the design and implementation of an integrated health monitoring system using an ESP32 microcontroller and various biosensors [6]. Using a Raspberry Pi 3 as a server and an ESP32 dev kit v1 for a wireless wearable sensor controller, Alsahi and Marhoon developed an intelligent healthcare system based on the IoT for the assessment of vital indicators such as temperature, pulse rate, ECG, and spo2. With the suggested approach, doctors can visit patients who oversee them and

save time by monitoring many patients [7]. This conference paper focuses on implementing an intelligent healthcare system based on IoT for the measurement of vital signs.

The modernized medical business has come with some challenges, which is why Pantawane et al. explored the types of problems patients face in hospitals and how smart technologies may or should assist physicians and nurses in addressing these problems [8].

According to Bansal et al., the main goal was to create a system that could use a sophisticated remote monitoring system to identify severe cardiac events in advance [9]. Using a global positioning system (GPS), an artificial neural network (ANN), and image processing (IP). GPS provides latitude, date, longitude, and time, which are used to calculate the azimuth angle of the Sun [10].

The modern quantum behavior technique, which is based on the Monte Carlo method and the Schrödinger equation, was introduced by Kaur et al. For efficient particle movement, the three fundamental steps of the suggested technique were also addressed and mathematically modeled. The effectiveness of the proposed method in resolving the dynamic nonlinear problem is evaluated. Experimental results show that the proposed method is superior to alternative methods in resolving nonlinear problems [11].

COMPONENT LIST

Hardware Requirement

- ESP32 Board
- MAX30100 Pulse Oximeter Sensor
- DS18B20 Sensor
- DHT11 Sensor
- Resistor 4.7K
- Connecting Wire
- Breadboard

Software Requirement

- Arduino IDE
- ESP32 Libraries
- Blynk APP

ESP32 Board

The ESP32 board plays a crucial role in the field of smart healthcare monitoring by enabling real-time data processing, transmission, and gathering. Its built-in Bluetooth and Wi-Fi allow it to easily communicate with sensors that measure important health factors such as blood pressure, body temperature, and heart rate. The ESP32 BOARD system is illustrated in Figure 1. Wearable health monitoring systems can benefit greatly from the ESP32's low power consumption, which enables continuous monitoring without the need for regular battery replacements. Furthermore, its adaptability to a range of healthcare applications, from aged care management to remote patient monitoring, is facilitated by its versatility and interoperability with various sensors. Additionally, ESP32's internet connectivity creates opportunities for cloud-based data processing and storage, thereby improving the scalability and accessibility of medical data.

MAX30100 Pulse Oximeter Sensor

There is great potential for improving the smart health care monitoring system with the ESP32 by utilizing the MAX30100 pulse oximeter sensor. This sensor is essential for the real-time monitoring of critical health factors because it can measure blood oxygen saturation levels and heart rate correctly.



Figure 1. ESP32 board.



Figure 2. MAX30100 pulse oximeter sensor.

The MAX30100 sensor, which is integrated into the system, allows for continuous, noninvasive monitoring of patient's physiological circumstances and offers insightful information about the state of their cardiovascular health. Healthcare providers can remotely monitor patients' vital signs by integrating the ESP32 microcontroller with the MAX30100 sensor. The MAX30100 pulse oximeter sensor is shown in Figure 2. This allows for early detection of irregularities and prompt intervention. Furthermore, the low power consumption of the ESP32 and sensor makes them appropriate for extended monitoring applications, providing uninterrupted operation without excess battery drain.

DS18B20 Sensor

In an ESP32-based smart healthcare monitoring system, a precise and accurate digital temperature sensor DS18B20 can be extremely important. DS18B20 sensor is shown in Figure 3. For several reasons, including the detection of fever, tracking changes in body temperature, and guaranteeing the efficacy of treatment, temperature monitoring is crucial in the medical field. By integrating the DS18B20 sensor with ESP32, patient temperatures may be monitored in real-time, allowing medical professionals to quickly see any deviations from normal and take the necessary action. For example, the DS18B20 sensor can be included in wearables or smart patches worn by patients in remote patient monitoring scenarios. In this manner, temperature data can be continuously transmitted to the ESP32 hub for analysis and to alert healthcare providers in the event of unusual readings.

DHT11 Sensor

In an ESP32-based smart healthcare monitoring system, the DHT11 sensor is essential. It is crucial to keep an eye on environmental conditions in healthcare settings because of its precision in measuring temperature and humidity. The DHT11 sensor can be used in wearable technology or placed in the patient's surroundings to continually monitor humidity and ambient temperature in the context of

healthcare monitoring. DHT11 sensor is shown in Figure 4. This information is crucial for ensuring patient comfort and safety, especially in places such as hospital rooms and assisted living homes where variations in humidity and temperature can harm health outcomes. Wireless temperature and humidity data collection, processing, and transmission were made possible by integrating the DHT11 sensor with the ESP32 microcontroller.

CIRCUIT DIAGRAM

The circuit schematic shows the fundamental design of an ESP32 microcontroller-based smart healthcare monitoring system. The central processing unit (CPU) of the system is the ESP32 board, which communicates with a variety of sensors to measure critical health factors including blood pressure, temperature, and heart rate. Data collection was made possible by the sensors' connections to the general purpose Input/Output (GPIO) pins of the ESP32 board. Furthermore, the ESP32 board incorporates wireless communication capabilities, typically via Wi-Fi or Bluetooth, allowing sensor data to be transmitted to external platforms or devices. ESP32 uses algorithms intended for tasks such as noise filtering and anomaly detection to handle and evaluate these data. The circuit diagram of the ESP32 microcontroller is shown in Figure 5. Processed data may also be sent to a cloud platform for remote access, analysis, and storage.

WORKING METHODOLOGY

The circuit schematic uses ESP32 microcontroller technology to demonstrate the core elements of a smart healthcare monitoring system, as shown in Figure 6. ESP32 functions as the main processor with different health sensors, including blood pressure, temperature, and heart rate sensors.



Figure 3. DS18B20 sensor.



Figure 4. DHT11 sensor.

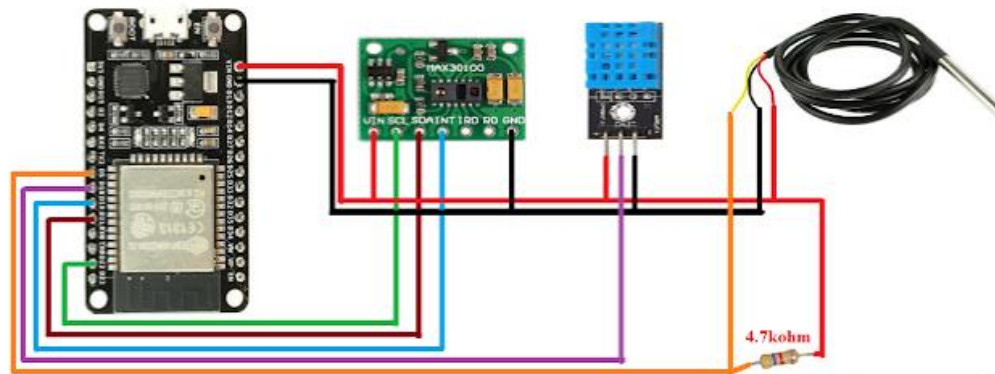


Figure 5. Circuit diagram of ESP32 microcontroller.

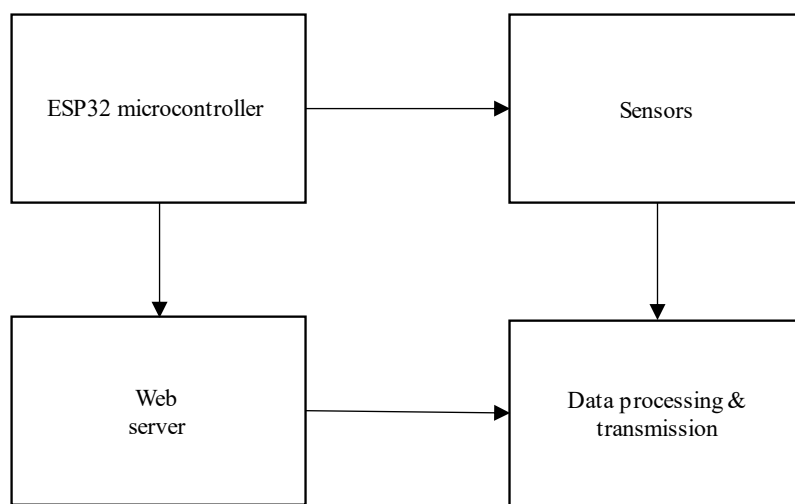


Figure 6. Block diagram of the health monitoring system.

These sensors collect essential health data, which the ESP32's built-in algorithms assess and evaluate. ESP32 integrated communication modules, such as Wi-Fi and Bluetooth, allow for the wireless transmission of processed data for additional analysis and cloud platform storage, allowing for remote access and monitoring. The system may also have a user interface that allows for real-time visualization and interaction with health data, as well as data storage capabilities for local backup. Facilitating early detection of patient care.

DESCRIPTION OF THE BLOCK DIAGRAM

The central component of the system, the ESP32 microcontroller, oversees data processing and transmission. They interact with a range of sensors that track various aspects of health. The DS18B20 waterproof temperature sensor measures body temperature, the BME280 temperature and humidity sensor examines room conditions, and the MAX30100 or MAX30102 pulse oximeter and heart rate sensor analyze heart rate and blood oxygen levels. ESP32 receives and processes data from these sensors. ESP32 uses its integrated Wi-Fi to send the analyzed data to a web server, enabling real-time health monitoring. The power supply used to power the system must be able to supply the 1.8V to 3.3V operational voltage of the ESP32. This technology offers a thorough and instantaneous health monitoring solution; however, it is crucial to ensure that it conforms to all applicable privacy and safety laws.

While this system offers a complete solution for health monitoring, it is crucial to remember that it must be developed and implemented in compliance with all applicable safety and privacy laws. This ensures that the system is secure, considerate of the patient's privacy, and efficient, as shown in Figure 7.

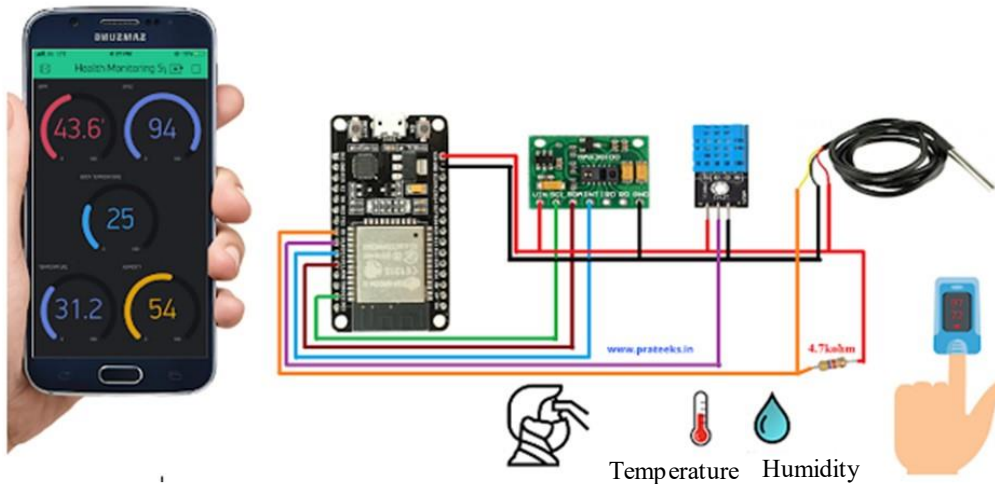


Figure 7. Health monitoring system using the Blynk App.

DISCUSSION

The effectiveness and influence of the system's features on patient care and healthcare delivery are included in the discussion of the results of smart healthcare monitoring systems. Examining the capacity of the system to offer real-time monitoring and early health anomaly identification is crucial. Through continuous collection and analysis of health data and vital signs, the smart monitoring system enables timely interventions that prevent problems and improve clinical outcomes. Furthermore, healthcare providers can foresee possible health problems and adjust tailored care plans according to the system's predictive analytics capabilities, which promotes more proactive and preventive approaches to healthcare management. Furthermore, the incorporation of telemedicine and remote patient monitoring functionalities facilitate smooth communication between medical practitioners and patients, thereby promoting increased accessibility to care.

CONCLUSION

The use of ESP32 in smart health monitoring systems is a major development in the field of healthcare technology. By harnessing the adaptability of the ESP32 microcontroller and the power of IoT, this system provides accurate, complete, and real-time health monitoring. This system can provide an in-depth overview of a patient's health status as it uses various sensors to monitor vital health markers. This improves the standard of service, while also providing patients with insightful information about their health.

In addition, the system is a very useful tool for medical practitioners, as it can send data to a web server for real-time monitoring. In the case of any health irregularity, it enables immediate intervention that can save lives, and the ESP32-based smart healthcare monitoring system is proof of how technology can completely transform the medical field. He emphasizes how critical real-time health monitoring is to improve patient outcomes and how IoT makes this possible. It also serves as a reminder that these systems must be developed and implemented in compliance with safety and privacy laws to protect patient rights and interests. The system is a step towards making healthcare more patient-centric and data-driven, not just technological advancement.

Acknowledgments

Acknowledgments recognize the contribution of funding bodies and anyone who has assisted with the work.

REFERENCES

1. Kher RK, Patel DM. A comprehensive review on wearable health monitoring systems. *Open Biomedical Engineering Journal*. 2021;15:213–225.

2. Selvaraj S, Sundaravaradhan S. Challenges and opportunities in IoT healthcare systems: A systematic review. *SN Applied Sciences*. 2020;2:139. DOI: 10.1007/s42452-019-1925-y.
3. Sujith AVLN, Sajja GS, Mahalakshmi V, Nuhmani S, Prasanalakshmi B. Systematic review of smart health monitoring using deep learning and artificial intelligence. *Neuroscience Informatics*. 2022;2:100028. DOI: 10.1016/j.neuri.2021.100028.
4. Kumar Sharma G, Tr M, translators. A deep analysis of medical monitoring system based on ESP32 IoT system. 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE); 2023. Greater Noida, India. p. 1848–1852. DOI: 10.1109/ICACITE574.10.2023.10182920.
5. Manjupriya R, Jayabharathi T, Sowmya AK, Dharani P, Nandhini S. An IoT-based smart patient health monitoring system using ESP32. *J Emerg Technol Innov Res*. 2024;11(2): e694-e696.
6. Murali K, Veerapandu G. Integrated health monitoring system with ECG, SCG, SpO2. *J Emerg Technol Innov Res*. 2023;10(6): e431-e439.
7. Alsahi QN, Ali F, Marhoon: Design health care system using Raspberry Pi and ESP32. *Int J Comput Appl*. 2020;177(36):33-38.
8. Pantawane R, Jyoti A, Sheoran S, Uikey Y, Sonarkar S, Thakare R. Implementation of IoT-Based Health Care and Saline Monitoring System Using Arduino UNO. In: Shaw RN, Das S, Piuri V, Bianchini M, editors. *Advanced Computing and Intelligent Technologies*. Springer Nature Singapore; 2022. p. 513–526. DOI: 10.1007/978-981-19-2980-9_41.
9. Bansal A, Kumar S, Bajpai A, Tiwari VN, Nayak M, Venkatesan S, Narayanan R. Remote health monitoring system for detecting cardiac disorders. *IET Systems Biology*. 2015;9:309–314. DOI: 10.1049/iet-syb.2015.0012. PubMed: 26577166.
10. Kumar K, Varshney L, Ambikapathy A, Mittal V, Prakash S, Chandra P, Khan N. Soft computing and IoT-based solar tracker. *Int J Power Electron Drive Syst*. 2021;12. DOI: 10.11591/ijpeds.v12.i3.pp1880-1889.
11. Kaur A, Kaur S, Dhiman G. A quantum method for dynamic nonlinear programming technique using Schrödinger equation and Monte Carlo approach. *Mod Phys Lett B*. 2018;32:1850374. DOI: 10.1142/S0217984918503748.