System for Remote Health Monitoring using Biosensor with IoT Cloud Convergence

Saurabh Bhattacharya
Research Scholar,
Department of Computer Applications
NIT, Raipur, India
babu.saurabh@gmail.com

Dr. Manju Pandey
Assistant Professor,
Department of Computer Applications
NIT, Raipur, India
mpandey.mca@nitrr.ac.in

Abstract

Without the Internet of Things, patients could interact with doctors through various forms of communication, such as visits, text messaging, and telephone. However, no technology allowed doctors to monitor patient's health remotely. With the Internet of Things (IoT) development, remote patient health monitoring has become possible. This has allowed doctors to provide the best possible care and improve the quality of life for their patients.It has also made it easier for them to interact with their patients.Remote monitoring of a patient's health has been shown to reduce the length of their stay in the hospital and prevent them from re-admissions. It has also brought about various improvements in their treatment.The field of electronic healthcare systems (EHS) is considered to be the most promising area of digital innovation. It involves the collection and use of data related to health conditions. Many of the sensors and devices used in this field are connected to the internet.In this paper, a remote monitoring system is proposed that allows patients to monitor their health through the Internet of Things with cloud convergence. 3877

Keywords: Remote Monitoring, Electronic Healthcare Systems (EHS), Biosensors, Internet of Things, Cloud computing.

DOI Number: 10.48047/NQ.2022.20.16.NQ880392 **NeuroQuantology2022;20(16):3877-3887**

1. Introduction

The rise of the Internet of Things (IoT) has created a new era of computing technology that enables people to connect various devices and sensors to the internet. This is a great technology that is very important for every field.IoT aims to allow people to interact with objects and living beings through sensors. It works by connecting various devices and sensors to the internet. This technology allows people to collect and analyze data about their surroundings. It can also be used to create a personalized and interactive environment.The rapid emergence of Artificial Intelligence (AI)[1] and the evolution of IoT has created a world where people are becoming smarter. In addition to monitoring and controlling various objects and living beings, it has also been used to improve the efficiency of multiple fields, such as transportation[2] and agriculture[3].The immense potential of IoT applications has created a world where people are becoming more connected. With the increasing number of sensors and the technological advancements that have occurred in the field of wireless networks, the technology is expected to provide people with variousvaluable and interactive services.

The upsurge of the Internet of Things (IoT) has brought about various innovations that can improve how people live. One of these is the establishment of networks that allow people to gather information about their surroundings. In addition, it has the potential to help improve the efficiency of medical services.However, due to the increasing number of people with chronic conditions and the complexity of their lives, many healthcare executives and experts are finding it challenging to develop effective solutions for the public and private sectors. For instance, as the number of individuals with Covid-19, Alzheimer's disease and other mental disorders continues to rise, the need for effective mental health care is becoming more prevalent.

Due to the increasing number of people who are interested in remote patient monitoring[4], the concept of this practice is becoming more prevalent. This is because it allows them to receive the necessary care outside of a hospital. In this context, developing electronic medical records[5] is also becoming more feasible.The concept of the restorative sensor correspondence framework aims to provide a framework for the development of remote patient monitoring systems. These systems can monitor a person's condition and provide the necessary information to their caregivers. Some of the gadgets used in this system include wearable devices that can measure various medical conditions.Eventually, IoT will allow healthcare providers to monitor and treat their patients using wearable devices. This will allow them to provide effective and personalized care. It is also expected that the IoT will play a significant role in the next generation of health service delivery.

As a developing nation, India has a rapid growth rate in various aspects of its economy. It has a huge potential to develop its medical industry, but it has the daunting task of providing adequate and quality healthcare to its citizens. The government has launched various e-health services to provide better and faster healthcare to the country's citizens. These include the National e-Health Authority, Aarogya Setu, and IHIP.Due to the emergence of the COVID-19 pandemic[6], many people have started adopting quarantine and social distancing as precautionary measures. However, these procedures can be very challenging due to the lack of regular communication with their medical providers.

An intelligent remote health monitoring system is proposed using the Internet of Things (IoT) technology, which can provide various medical services such as monitoring a person's Oxygen saturation (SpO_2), heart rate, and body temperature. This system can be helpful for patients from rural areas who require regular or constant monitoring and elderly personsas it can help clinics keep track of their patients' health conditions. The system will notify the doctor or other healthcare providers if a change occurs.Through cloud computing, doctors can take action on their data and improve patient care quality.

The remainder of the paper is arranged as follows section-2 discusses our contribution, section-3 discusses significant existing work in remote monitoring of patients, section-4 deals with the methodology implemented to achieve the outcome, section-5 discusses the results and the last section concludes the paper.

2. Our Contribution

A patient monitoring system is a vital part of any healthcare facility's operations, as it allows doctors to identify early warning signs of a patient's deteriorating health and provide the necessary treatment. It can also help them save lives by providing them with the necessary information to make informed decisions.A patient monitoring system is used to measure various vital signs of a critically ill patient continuously. These include their heart rate, body temperature, respiration rate, and oxygen saturation.The proposed system incorporatesthe following contribution.

i. Quick measuring and transferring of data via the cloud.
ii. Easy to use and negligible error rate.
iii. The facility of sending reports to mail.
iv. Live remote monitoring with high accuracy.
v. Low cost and easy to use.

The concept of the healthcare Internet of Things (IoT) can transform the way healthcare is delivered. It can help improve the efficiency and effectiveness of the medical profession by allowing patients and healthcare workers to interact with each other and with the devices in their homes. It can also be used to add other home appliances to the system. One of the most important factors that can be considered when implementing an IoT system is providing a timely and accurate signal to a healthcare worker. This can help prevent human error from happening and improve the efficiency of the patient's care. Another advantage of this system is the ability to send an email alert to the patient's relatives and specialists if the patient's physiological parameters exceed the limit. One of the most exciting features of the proposed system is the ability to create the ideal environment for a patient's well-being. This can be done by sending data to a control unit, which will then utilize the information to create the ideal room conditions.

3. Related Work

This paper aims to develop a comprehensive approach to improve the efficiency and effectiveness of the healthcare system by developing a low-cost and portable remote monitoring system. This system should provide doctors, patients, relatives and caregivers with the necessary information. However, there are a variety of drawbacks of available in the existing system, such as their bulky, missing required parameters and slow response time. Some significant works are described below.

Author & Year	Sensor/ Method Used	Finding	Limitation
Khairul Islam et al. [7][2022]	DHT11, MAX30100, LM35, MQ-135	Monitoring asthma patient	Limited to the asthma patient
S.Balakrishnan et al. [8][2022]	RFID wrist band	Health monitoring based on machine learning	Patient body temperature and SpO_2 is missing
Wasana Boonsong et al. [9][2022]	MLX90614	Contactless body temperature of the patient	Only monitor Body temperature
Vaneeta Bhardwaj et al. [6][2022]	BP0001, MLX9061, MAX30100	Basic physical parameters of the patient	No Heart rate monitoring
M. Pravin Savaridass et al. [10][2021]	LM35, LM358, Pulse oximetry	Basic physical parameters of the patient	No live monitoring
Hoe Tung Yew et al.[11] [2020]	ECG Signals	Monitoring cardiac patient	Limited to cardiac patient
Dev Gupta et al.[12] [2020]	LM35, Blood pressure machine, MAX30100	Health monitoring for obese adults.	Limited to the obese patient, heavy device setup
M.A. Akkas et al. [13][2020]	31392B1, 3044	Basic physical parameters of patient	Limited to live monitoring

Samira Akhbarifar et al. [14][2020]	Generalize data	Hypertension and heart disorder	Limited to cloud technology
Rinto Priambodo et al. [15][2020]	Bluetooth based oximeter	Oxygen saturation and heart beat	Body temperature missing
Munish Manas et al. [4][2019]	LM35, PPG signals	Heart rate and fall situation	Only limited to heart beat
B.Lakshmi Dhevi et al. [16][2018]	Medical Images	Transmission of medical image	Time consuming, need advance images for monitoring
Sunil Kumar Prabhakar et al.[17] [2017]	EEG Signal	Identifying epilepsy using EEG signals	Only for Epilepsy

4. Methodology

The concept of an IoT-based health monitoring system is very different from that of a traditional healthcare system. Due to the system's nature, achieving the necessary performance and results through the IoT is very challenging. The various components of the system, such as sensors, detectors, and microcontrollers, are connected for synchronization.

The sensors and detectors are designed to detect the signals in the form of an analog signal. First, they mustbe converted into a digital format to perform their functions. This process is carried out through multiple components, such as the microcontroller and the digital converter. The most popular and widely used type of device for this type of project is "*Arduino Mega 2560 R3*".After the conversion of the data, the data is transmittedto the cloud using "*Blynk*" for remote monitoring. The readings are then analyzed to see the variations in the values. The block diagram in fig. 1 shows the various steps involved in the process.

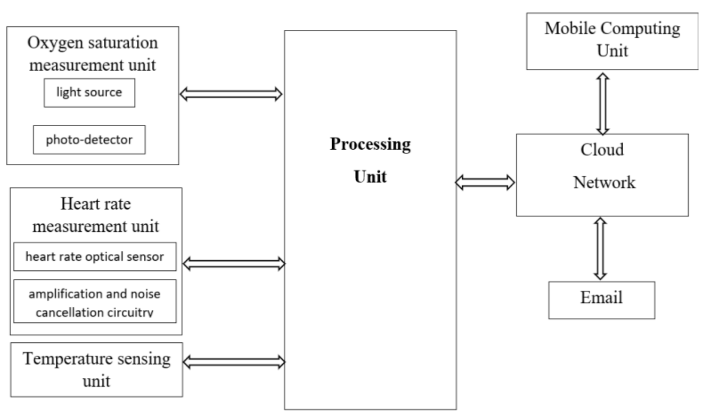

Fig. 1 Block diagram for proposed monitoring system

The concept of the Internet of Things refers to a system that enables devices to collect and transmit data from the environment. It uses a combination of hardware, sensors, and processors to perform various tasks. The use of cloud computing facilitates its remote access through a wireless cloud.The IoT aims to enable devices to communicate with each other and with other smart devices outside their home.

There are four phases in the development of the system. The first one is to connect all the various components of the system to a central hub. This process then allows the data collected to be analyzed.The system usually consists of various sensors that can be wireless or wired. In stage 2, the related data is collected to allow it to linked to the internet. This process is carried out through a process known as digital conversion. In stage 3, the data preprocessing is carried out through IT systems.The data collected during the final stage is then transmitted and stored in a cloud-based system. This method allows the end-users to access the data when they need it.

The flowchart Fig. 2 shows the various steps that were performed in the process, including setting up protocols and reading sensor values. It also shows the sequence of steps, such as the start of the process, the execution of the protocols, and the sending of the measure values to the cloud server.

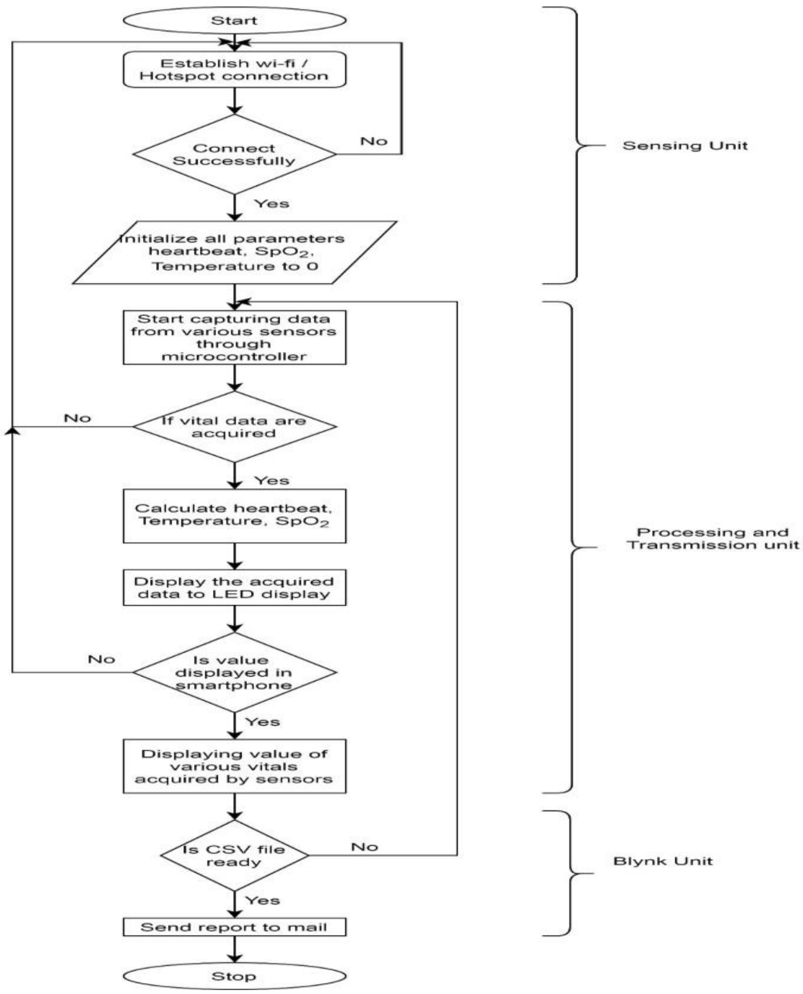

Fig. 2 Dataflow Diagram

4.1 Sensor Integration

The proposed patient remote health monitoring system, uses multiple sensors and the Internet of Things (IoT) platform to collect and analyze data about a person's physiological condition. It can then be sent to the cloud. The system can measure various parameters such as heartbeat, temperature, and oxygen saturation content.In addition, a system that continuously monitors the data collected by the system is developed to allow the caregiver, doctor and relatives to analyze the data and act accordingly.

4.1.1 Heart Beat Sensor

Heart rate data provide valuable information about the patient, which may be used in the automated and other microcontroller-based projects. Although reading this data is a difficult task, to solve this problem, the pulse sensor that makes it easy to understand the rate of heartbeat. It consists of a primary optical heart rate sensor with noise cancellation and amplification circuitry capabilities that provide a simple and easy way to get a steady pulse reading. The deployed sensor works over 3vto 5v.

The pulse wave is identified through the optical heart sensor, which pinpoints the changes in the density of blood vessels since these vessels are changed due to the pumping action of blood. Changes in density are identified by pulse wave using an optical sensor and colored green led. Pulse sensor uses optical fiber that eliminates the noises such as ambient light and infrared rays. Thereby we get the high-quality signals of pulses.

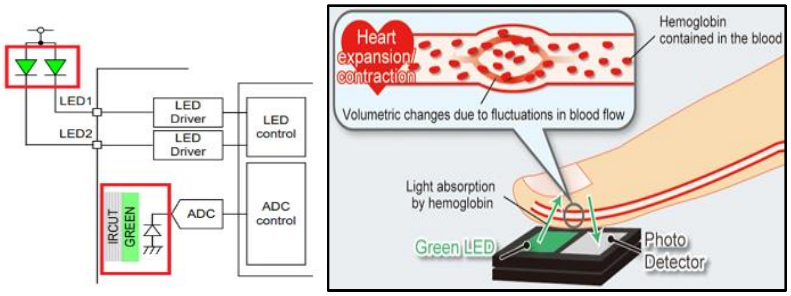

Fig. 3 Measuring Heartbeat[18]

The calculation for Heart rate

Sum $=\sum_{i=1}^{30} FreqMeasure.read()$

Frequency = Received value/(sum/30)

Beats per Minute =frequency$*$60

4.1.2 Oxygen Saturation (SpO_2)

SpO_2 stands forperipheral capillary oxygen saturation(SpO_2) is used to measure the percentage of oxygen blood carries inside the body, which is vital for observation and of utmost importance. The normal SpO_2 for a healthy individual is in the approximate range of 95 to 99, but a few factor's such as elevation, the patient having asthma or chronic heart disease and various other factor affect it. Oxygen is most important for a vital organ such as the brain; if they do not get enough, they might suffer unrecoverable damage.

For transmission purposes, we use the transmitter, which is the led and receiver. Measuring value place the sensor on the opposite side of the finger, and in between the photo-detector and led place the person's finger.so the emitted light will be absorbed by the finger, and some part of the finger is within reach of the photo-detector.

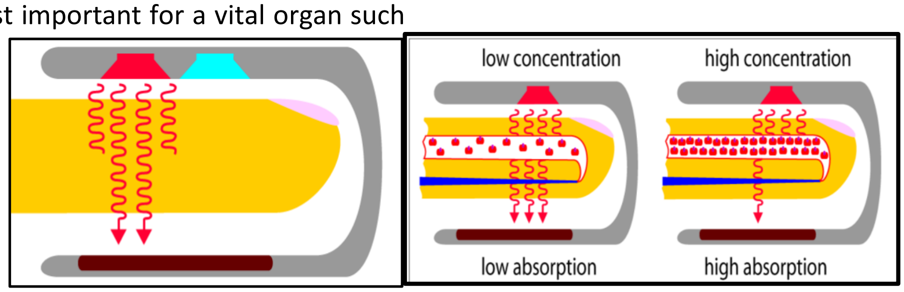

Fig. 4 Measuring Oxygen Saturation[19]

4.1.3 Temperature Sensor

The thermistor is a combination of the word Thermal and Resistor. The temperature sensor consists of semiconductor material that shows greater resistance modification w.r.t to the slight temperature change. This temperature sensor is easy to use and can even check the single-point temperature.Thermistors are a robust, cost-effective, and sensitive type of device that can be used to measure temperature. They are made up of either glass or epoxy and can be shaped in various ways, such as beads, rod, and disc. Thermistors are devices designed to measure a component's temperature by measuring its resistance. There are two types of thermistors: the positive temperature coefficient (PTC) and the negative temperature coefficient (NTC). The former increases the value of its resistance as the temperature increases, while the latter decreases the value as the temperature gets lower.The most common types of thermistors are NTC thermistors. With a PTC thermistor, the value temperature will increase and decrease with the changes in resistance.

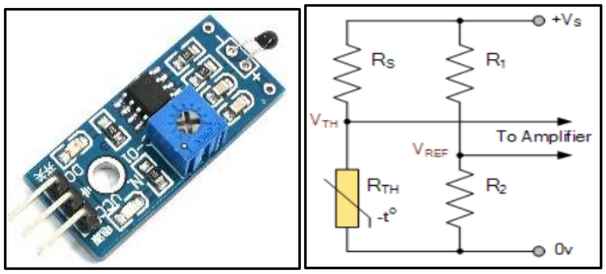

Fig. 5 Glass Bead Thermistor[20]

The calculation for body temperature

Transformation of received voltage to temperature:

Temperature (in degree Celsius)-

Temperature = Output voltage∗0.4881

4.2 Standard Values for reference

Table 1 Standard values for various parameters[21]

S. N	Parameter	Normal Range (Adult)	Normal Range (Infant)	Decision	
				Above Normal	Below Normal
1.	Heart Beat	55-100 bpm	80-150 bpm	Tachycardia	Bradycardia
2.	SpO_2 Oxygen Saturation	95-99 %			Hypoxemia
3.	Body Temperature	> 0.6 °C <= 37°C		Hyperpyrexia	Hypothermia

4.3 Working of the System

The proposed system consists of three separate subsystems. The first one is the main microcontroller known as ATmega2560. This subsystem mainly functions as the central controller, communicating with other subsystems through wireless communication. The second one is a set of sensors that can measure various physiological parameters, such as heart rate, oxygen saturation and body temperature. The third subsystem of the Blynk app a cloud-based data transmission system that enables users to send and receive live data over the internet. It also provides a variety of data formats, such as time-based and acute observations. A communication unit can control the data through the device's microcontrollers. Through Blynk, various sensors can be connected to the user interface of a tablet or smartphone and collect data about the user. This private server can help prevent unauthorized access to the data.

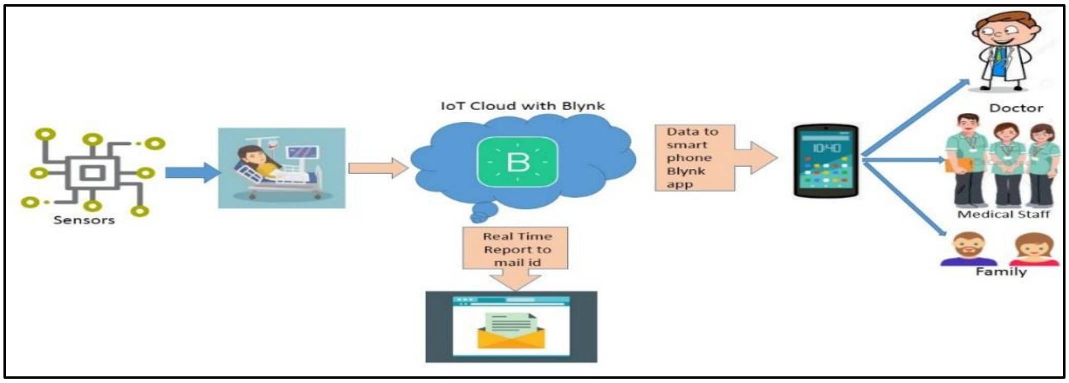

Fig. 6 Working of Health Monitoring System in the IoT environment

Sensors gather ambient data from the patient using various sensors and send it to the main microcontroller which further processes the data which are sent by sensors separately and then simultaneously sends all the data to smartphones/ tablets using blynk webserver for real-time monitoring. The doctors, medical staff, family members or caregiver can access the readings of each sensor from any place at any time and be able to watch keenly and take necessary action. Furthermore, various sensors data reports logged as per the necessity of data analysis purpose in future send to the registered mail id as CSV file format. The proposed system would allow people to measure their vital health conditions easily and quickly. It would be very cost-effective to implement. There were many devices that generated raw data and medical calculations. It helps avoids the up-front interpretation and time loss associated with medical calculations. It provides a simple and understandable format.The proposed system's primary function is to provide live data of patients who are under monitoring. Also, able to provide time-based analysis of vital indexes, i.e. summarized data for 1 hour or 3 hours, which helps to analyze the patient's condition.

5. Results and Discussion

The prototype of a remote health monitoring system (fig. 10 and fig.11) is tested on various subjects to evaluate its performance. In addition, various patient parameters, namely, heart rate, body temperature, and SpO_2, were analyzed fig 7 to fig. 9. The data collected during the evaluation can be compared with the commercial sensors*(standalone system)* available, namely for body temperature "*Dr. Morepen*" (Model - MT111) for the heartbeat and SpO_2 "*CLEAN MEDS*" Fingertip Pulse Oximeter.

*Fig. 7*Comparison of SpO2

Fig. 8 Comparison of Temperature

Fig. 9 Comparison of Heat beat

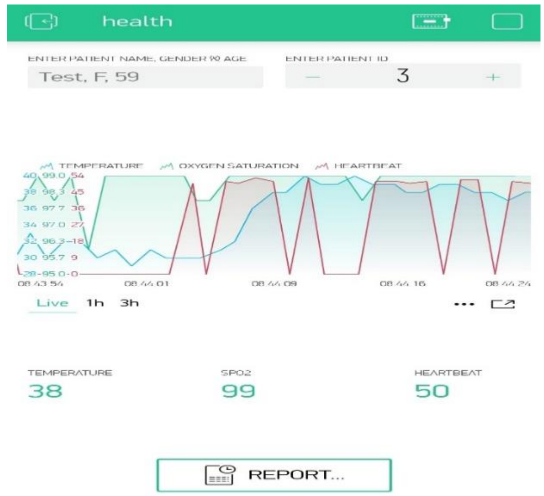

*Fig. 10*Home Screen

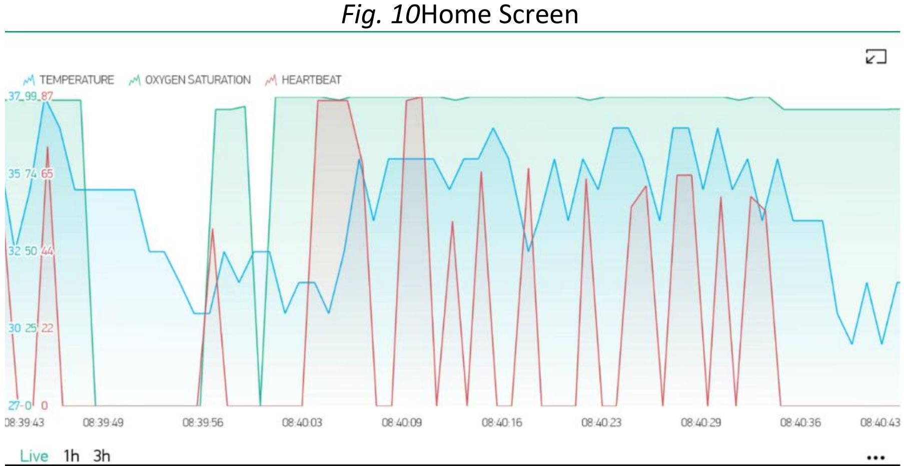

Fig. 11 Live Monitoring Graph

Table 2Comparison of proposed system and existed system

Criteria	Proposed System	The system with the local server	Standalone System
Accuracy Level	High	High	High
Security	High	Medium	Low
Cloud convergence	High	Not available	Not available
Operating System Dependency	Low	High	NA
Data Transmission Rate	High	Low	Not available
Authorization Token for security	Available	Not available	Not available
Time to read data	Fast	Fast	Slow

From the table-2, concludesthat the proposed cloud-based remote health monitoring system provides high security and accuracy. It eliminates the need for an operating system and allows us to transmit data without any delay. The system uses an authorization token to ensure that the data is secure. In addition, Blynk's support for sending data is swift compared to the local server.

6. Conclusion

The system developed using biosensors incorporated with the cloud works seamlessly with negligible errors. From sensing the patient's vital signs to sending it to the cloud, the system ensures that the information is sent to the correct person. It also allows the medical staff to view it using their smartphones. The project's accessibility between the Blynk server and the Arduino Mega R3 is one of the most crucial components of the project. We can easily get the data values through the framework, which is composed of the Blynk libraries and the authorization token. In addition, the Blynk as cloud convergence is also very efficient in communicating with the equipment. The proposed system aims to address various challenges faced by the healthcare industry, such as increasing the cost of providing healthcare services and the shortage of skilled and experienced healthcare providers.Despite the advantages of having a secure and trusted system, it still faces some technical issues that need to be resolved before healthcare providers and actors can fully implement it.The proposed system will in no way exclude the involvement of medics. This only benefits doctors and patients by allowing them to respond to patients' needs promptly.

References

[1] A. Kishor and C. Chakraborty, "Artificial Intelligence and Internet of Things Based Healthcare 4.0 Monitoring System,"*Wirel. Pers. Commun.*, no. 0123456789, 2021, doi: 10.1007/s11277-021-08708-5.

[2] A. Bhargava, D. Bhargava, P. N. Kumar, G. S. Sajja, and S. Ray, "Industrial IoT and AI implementation in vehicular logistics and supply chain management for vehicle mediated transportation systems,"*Int. J. Syst. Assur. Eng. Manag.*, vol. 13, no. s1, pp. 673–680, 2022, doi: 10.1007/s13198-021-01581-2.

[3] N. Gavrilović and A. Mishra, "Software architecture of the internet of things (IoT) for smart city, healthcare and agriculture: analysis and improvement directions,"*J. Ambient Intell. Humaniz. Comput.*, vol. 12, no. 1, pp. 1315–1336, 2021, doi: 10.1007/s12652-020-02197-3.

[4] M. Manas, A. Sinha, S. Sharma, and M. R. Mahboob, "A novel approach for IoT based wearable health monitoring and messaging system,"*J. Ambient Intell. Humaniz. Comput.*, vol. 10, no. 7, pp. 2817–2828, 2019, doi: 10.1007/s12652-018-1101-z.

[5] M. Hamim, S. Paul, S. I. Hoque, M. N. Rahman, and I. Al Baqee, "IoT Based remote health monitoring system for patients and elderly people,"*1st Int. Conf. Robot. Electr. Signal Process. Tech. ICREST 2019*, pp. 533–538, 2019, doi: 10.1109/ICREST.2019.8644514.

[6] V. Bhardwaj, R. Joshi, and A. M. Gaur, "IoT-Based Smart Health Monitoring System for COVID-19,"*SN Comput. Sci.*, vol. 3, no. 2, pp. 1–11, 2022, doi: 10.1007/s42979-022-01015-1.

[7] K. Islam, F. Alam, A. I. Zahid, M. M. Khan, and M. Inamabbasi, "Internet of Things-(IoT-) Based Real-Time Vital Physiological Parameter Monitoring System for Remote Asthma Patients,"*Wirel. Commun. Mob. Comput.*, vol. 2022, 2022, doi: 10.1155/2022/1191434.

[8] S. Balakrishnan, K. Suresh Kumar, L. Ramanathan, and S. K. Muthusundar, "IoT for Health Monitoring System Based on Machine Learning Algorithm,"*Wirel. Pers. Commun.*, vol. 124, no. 1, pp. 189–205, 2022, doi: 10.1007/s11277-021-09335-w.

[9] W. Boonsong, N. Senajit, and P. Prasongchan, "Contactless Body Temperature Monitoring of In-Patient Department (IPD) Using 2.4 GHz Microwave Frequency via the Internet of Things (IoT) Network,"*Wirel. Pers. Commun.*, vol. 124, no. 3, pp. 1961–1976, 2022, doi: 10.1007/s11277-021-09438-4.

[10] M. P. Savaridass, N. Ikram, R. Deepika, and R. Aarnika, "Development of smart health monitoring system using Internet of Things,"*Mater. Today Proc.*, vol. 45, pp. 986–989, 2021, doi: 10.1016/j.matpr.2020.03.046.

[11] H. T. Yew, M. F. Ng, S. Z. Ping, S. K. Chung, A. Chekima, and J. A. Dargham, "IoT Based Real-Time Remote Patient Monitoring System," in *2020 16th IEEE International Colloquium on Signal Processing & Its Applications (CSPA)*, Feb. 2020, no. Cspa, pp. 176–179, doi: 10.1109/CSPA48992.2020.9068699.

[12] D. Gupta, A. Parikh, and R. Swarnalatha, "Integrated healthcare monitoring device for obese adults using internet of things (IoT),"*Int. J. Electr. Comput. Eng.*, vol. 10, no. 2, pp. 1239–1247, 2020, doi: 10.11591/ijece.v10i1.pp1239-1247.

[13] M. A. Akkaş, R. SOKULLU, and H. Ertürk Çetin, "Healthcare and patient monitoring using IoT,"*Internet of Things (Netherlands)*, vol. 11, no. 2020, p. 100173, 2020, doi: 10.1016/j.iot.2020.100173.

[14] S. Akhbarifar, H. H. S. Javadi, A. M. Rahmani, and M. Hosseinzadeh, "A secure remote health monitoring model for early disease diagnosis in cloud-based IoT environment,"*Pers. Ubiquitous Comput.*, 2020, doi: 10.1007/s00779-020-01475-3.

[15] R. Priambodo and T. M. Kadarina, "Monitoring Self-isolation Patient of COVID-19 with Internet of Things," in *2020 IEEE International Conference on Communication, Networks and Satellite (Comnetsat)*, Dec. 2020, vol. 15, no. 2, pp. 87–91, doi: 10.1109/Comnetsat50391.2020.9328953.

[16] B. Lakshmi Dhevi, K. S. Vishvaksenan, K. Senthamil Selvan, and A. Rajalakshmi, "Patient Monitoring System Using Cognitive Internet of Things,"*J. Med. Syst.*, vol. 42, no. 11, 2018, doi: 10.1007/s10916-018-1095-2.

[17] S. K. Prabhakar and H. Rajaguru, "Development of patient remote monitoring system for epilepsy classification,"*IFMBE Proc.*, vol. 61, pp. 78–85, 2017, doi: 10.1007/978-981-10-4220-1_16.

[18] B. Hannon and M. Ruth, "Heart Beat,"*Modeling Dynamic Biological Systems*. pp. 141–146, 2014, doi: 10.1007/978-3-319-05615-9_17.

[19] "Pulse oximeters.,"*Rn*, vol. 63, no. 8. pp. 65–68, 2000.

[20] Aspencore, "Thermistors and NTC Thermistors,"*ElectronicsTutorials*. 2021, [Online]. Available: https://www.electronics-tutorials.ws/io/thermistors.html.

[21] “vital-signs-body-temperature-pulse-rate-respiration-rate-blood-pressure.” .