MJSAT

Malaysian Journal of Science and Advanced Technology

journal homepage: https://mjsat.com.my/

Investigation into Smart Healthcare Monitoring System in an IoT Environment

Salini Pradhan[1], Ahmad Anwar Zainuddin [*1], Rohilah Sahak[2], and Muhammad Farhan Affendi Mohamad Yunos [1]

[1]*Department of Computer Engineering and Computer Science, School of Engineering, Manipal International University, Nilai Negeri Sembilan, Malaysia.*

[2]*Silverseeds Lab Network, Gombak, Selangor, Malaysia.*

KEYWORDS

Health Monitoring
IoT
Sensor
Raspberry Pi Model B+

ARTICLE HISTORY

Received 22 June 2022
Received in revised form 27 June 2022
Accepted 28 June 2022
Available online 30 June 2022

ABSTRACT

Continuous monitoring of progress of a clinical trial is known as health monitoring. It is to assure compliance with policy, best clinical practice, regulatory norms, and standard operating procedures. Monitoring is vital in several health settings. This creates an environment where physician and patient can engage. The doctor may also be up to date with the current patient's health status. Sensor initialization is this system's first stage. This project includes of many sensor kinds such as blood pressure sensor, temperature sensor, pulse rate sensor. The sensor is then connected to the Raspberry Pi 3 Model B+ which transmits a signal over the internet allowing the doctor to interact with patient data. All sensor data is stored in a cloud database. If the sensor value exceeds the threshold sensor value and the alert email is sent to the doctor and caretaker, then a precautionary notification is sent to the patient. Doctor and patient can interact through a user application where the doctor can even write the patient's prescription. This approach can monitor several patients in severe conditions and save time. This project provides low-cost monitoring from one's home. This is a secure and reliable project that helps patients worldwide.

1. INTRODUCTION

It is undeniably a good health is fundamentally link to people wellbeing which a good health can enable people to have the optimum condition to pursue their desire towards a better life. However, the global health crisis has produced a challenge due to a number of issues, including poor health services, vast inequalities between rural and urban areas, and physician and nurse shortages at critical times [1]. All machines are interconnected as Internet technologies improve. We can make many things more effective and simpler for human life by advancing technology. The most up-to-date medical technology and communication techniques can assist in lowering healthcare costs [2].

Internet-of-Things (IoT) has become increasingly important in daily life of people, and IoT technologies have advanced dramatically over the years. IoT is used to connect technology in a variety of industries, such as health monitoring, sensor networks, artificial intelligence, smart homes, and so on, and to transmit the results. The idea behind IoT is to collect reliable data from things and communicate it effectively using existing infrastructure [3]. Real-time analyzation is a vital of an IoT, thus the main motive of this proposed system is to establish a smart health device depending on the robust IoT tools, with the help of a microcontroller known as the Raspberry Pi Model B+ [4].

The abovementioned goals will be taken into consideration with reference to our earlier work [5]. Since the module is wireless, there are no problems with mobility and the module may be freely relocated [6]. This paper aims to review the health monitoring system. The sensor nodes on the patient's side are to monitor the patient's symptoms [7]. Blood pressure, heartbeat, temperature, and blood oxygen are the used sensors. The data is collected by these sensors and sent to a server. The server will then process the acquired monitor data and make it available to

*Corresponding author:
E-mail address: Ahmad Anwar Zainuddin <ahmad.anwar@miu.edu.my >.

other users, such as the cloud, doctors, and caregivers, in order to detect and monitor health issues [7]. Fig. 1 gives a descriptive analysis on how the smart healthcare device helps people and makes their life easier.

The paper is arranged as follows: Section I introduces the reader to the detailed study of IoT based health monitoring system using Raspberry Pi. Section II elaborates the literature review followed by some information pertaining to the proposed system. Section III focuses on the smart healthcare monitoring system with an emerging environment and opportunities as well as difficulties. Section IV discusses on all the research methodology of smart healthcare monitoring system Section V describes the various ways the proposed system can to developed. Finally, section VI summarizes how this healthcare monitoring system plays a vital role on people's life.

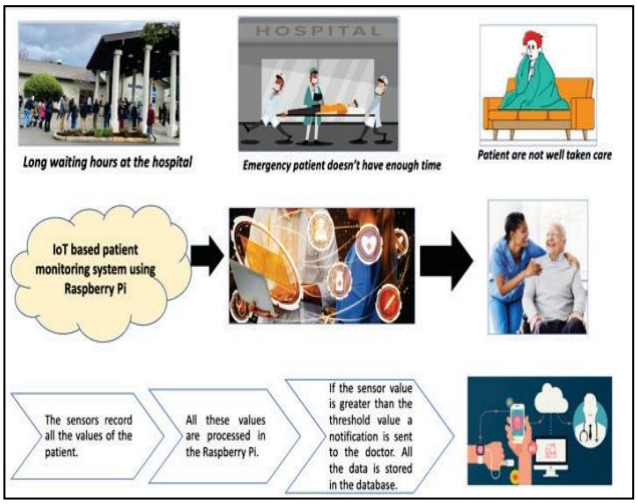

Fig. 1. The Graphical Abstract of IoT based Smart Healthcare device monitoring system

2. LITERATURE REVIEW

Literature review have been done in the previous paper [8][9]. Table 1 shows the details of the literature review.

Table 1. The details of literature review

Author(s) & Year	Variables Studied/ Research Design	Equipment/ Instruments/ Apparatus used for Experiments/Analysis/ Characterization, etc.	Important Findings	Limitations of Study
[10]	Availability of physician Availability of hospitals nearby	Raspberry Pi 3, Cloud computing, Internet of Things	The system concept includes sensors, databases, gateway devices, medical accessibility and hospital data to help the health related IoT network patrician.	There are no notification services available.
[11]	Rate of respiration of the patient Temperature of the patient Rate of heartbeat of the patient, Rate of accelerationof the patient	Raspberry Pi board Respiration Sensor Accelerometer Sensor Temperature Sensor Internet of Things	Patients can record their healthstatus in their own mobile phone andthen store the information using this technology advancement.	There are no notification services available.
[12]	Patient's body temperature, ECG, heart rate parameter, blood pressure, Electrical Electrical activity ofthe heart, Rate of movement	Temperatur esensor, BP sensor, heartrate sensor, an ECG sensor, acceleration sensor, raspberry Pi with GSM	A doctor can review a patient's medical history and recommend medicine and prescription adjustments. Patients with special IDs and passwords haveaccess to their records.	Data transmission is contingent on the presence of a smartphone.
[13]	Rate of respiration of the patient, Temperature of the patient, Rate of heartbeat ofthe patient, Rate of acceleration of the patient	Raspberry Pi board, Respiration sensor, Accelerometer sensor, Temperature sensor	The alarm system,which comprises of a buzzer and LED, warns the doctors when the threshold value is reached.	There are no notification services available.
[14]	Blood pressure measurement of the patient, Heart beat rate of the patient, Alcohol detection, Electrical activity of the heart	Raspberry Pi2, Blood pressure machine, Heart beat sensor, Alcohol sensor, EMG sensor, Sound sensor, ECG sensor, Video camera	The system has two modes of operation: adult patient monitoringand infant monitoring. The acquired datacan be seen locally as well as globally over the internet.	There are no notification services available.

3. SMART HEALTHCARE MONITORING SYSTEM IN AN IOT ENVIRONMENT

3.1 Smart Healthcare Monitoring System

In hospitals, where a patient's condition must be monitored on a frequent basis, this is normally done by doctor or other paramedical personnel who constantly monitors critical metrics including body temperature, heartbeat, and blood pressure. As a result, after some time, this task becomes tedious. Many studies have attempted to communicate patient data from a sender device to a receiver device using SMS (short message service) with GSM (global system for mobile communications) or RF (radiofrequency) module. Furthermore, the patient's

history is not provided in these circumstances; only current data is provided. So, the goal of this project is to continually monitor the data of the patient and, if the sensor value is greater than the threshold value an alert message is sent to the doctor. The Raspberry Pi links the senor with the cloud database. All the sensor data will be able to get stored in the cloud database and make it accessible from anywhere in the globe with the help of the Raspberry Pi. As a result, clinicians will be able to view the patient's medical history at any time and from anywhere. Designers will be able to monitor patients remotely via mobile or personal computer (PC) [15].

As a result of our fascination with the use of IoT and the work of other researchers, we will construct a prototype to monitor the patient's health condition locally and from a webpage that can be managed from a mobile phone or PC. In this proposed system, Raspberry Pi Model B+ was used. We can verify these values from anywhere on our Smartphone by viewing this webpage from either the Smartphone or the PC. Raspberry Pi contains Wi-Fi from within those helps to communicate with the internet and the microprocessor. The patient's data is sent to a webpage via the cloud using a Raspberry Pi 3 in this project. This program displays the status of the patient's health whenever we open it. They kept the gear with inbuilt Wi-Fi coupled to a sensor such as temperature, heartbeat on patient's side. Anyone can verify these values on our Smartphones from anyplace by viewing this webpage directly from the phone. The main processor utilized in this project is the Raspberry Pi 3, and communication between the internet and our hardware is established utilizing inbuilt Wi-Fi [15].

3.2 Emerging of a Smart Healthcare Monitoring System in IoT Environment

The Internet of Things enables devices to be sensed and controlled remotely through network infrastructure, resulting in Direct Interaction with sensors over network architecture, which improves system accuracy and reliability while reducing human interaction [16]. As the physical world is incorporated into computer-based systems, the Internet of Things presents enormous opportunity. As a result of this integration, human engagement is decreased, efficiency is increased, and accuracy is improved. Keeping a patient under close observation and monitoring vital indicators such as pulse rate, blood pressure, and core temperature is a critical occurrence in healthcare monitoring systems [17].

IoT sector is progressing to cut the price and patient experience while also ensuring that patients receive appropriate medications and live a long life. Undiagnosed health risks can be handled in traditional health care with IoT, that assures medical care through keeping a unique identification for every person, lowering the risk of issues. Through connectivity in between medical sensing element and your desktop or cell phone, that can interface using your host via configuration, decreases overall total price also minimizes time consumption [18].

3.3 Opportunities and Difficulties Smart Healthcare Monitoring System in IoT Environment

The volume, velocity, variety, veracity, and value are frequently used for the explanation of big data. The quantity of data produced is referred as volume, while rate at which it is produced is referred to as velocity. Variety is known as the wide range of the types of data available, whereas veracity is known as the unpredictability of what types of data that may be introduced in the future. Likewise, value is known as the quantity of data that can be obtained from a huge set of data. The cloud database is beneficial for preserving enormous quantities of data in a way that allows value to be extracted. In this approach, both clinical symptoms as well as the regularity of doctor appointments were tracked in the patient's medical records. The information can subsequently be used by algorithms to evaluate the health diagnosis [19].

Cloud technologies can handle a variety of data processing tasks, but computational offloading and machine learning are the most important. Complex data processing is sent to the cloud via computational offloading, which is beyond the capabilities of reduced wearable technology. By sending raw or partially processed sensor data to the cloud, the computing capacity of multiple devices can be utilized for processing. Using such a heavy computer network rather than loading on a singular smartphone has several benefits, including the ability to run more advanced analytics, produce results much quicker, as well as lengthen mobile device power consumption due to less embedding. Complex sensor nodes that quantify electromyography (EMG) signal, sugar levels, or accelerometers for object tracking would benefit greatly from parallel computing unloading. An electrocardiogram (ECG) signal, for example, have a consistent structure, and deviations from it can indicate a variety of heart problems, such as heart failure, cardiac infection, and even heart attack. The difficulties in Smart Healthcare Monitoring System are that IoT allows for greater flexibility, for example, if a patient requires constant care, he or she can remain at home rather than in a hospital and be monitored on a frequent basis utilizing IoT technology.

Some wearable gadgets, such as sensors, make the patient's body unpleasant [20]. The data transferred from the sensor to the control device and then to the monitoring center will be affected by noise, lowering the data quality. A better architecture aids in the transmission of data without compromising its integrity. The use of a noise-reduction technology can also aid to improve the data signal. Most available ECG monitoring methods utilize a guided signal analysis. This raises the cost, and it may result in a detection error. Machine learning can be used to analyze signals, resulting in increased efficiency and lower costs. The quantity of energy required to process sensors and devices increases as the number of them increases, leading in greater power consumption and energy leakage.

4. RESEARCH METHODOLOGY

This section explains the research methodology that has been used for this project. The initial task of an IoT based smart healthcare monitoring system, according to the workflow, is to collect data from patients via sensors. Temperature, ECG, blood pressure, and heartbeat rate are examples of health parameters. Low-power sensors are placed in such systems. They gather information from patients on a regular basis. The health state of a particular patient is observed using this often-collected data, and necessary medicines are given. This data is displayed on a Raspberry Pi board-connected LCD display, and if necessary, it is processed before being transferred to an IoT server for storage, from which it is accessible to the system's intended clients. As a result, this system is based on the client-server model of computer networking. The data acquired on the IoT server is saved for all peers in the system's reference and delivered to them as needed. Fig. 2 shows the Smart Healthcare

system works with the basic steps. These steps are implemented to develop this Smart Healthcare Device using Raspberry Pi.

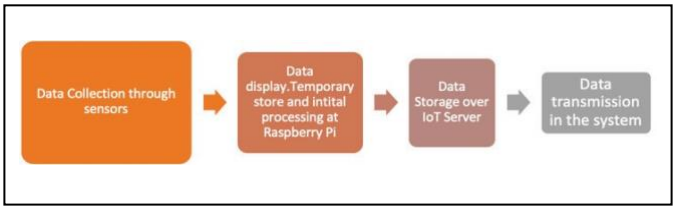

Fig. 2. The basic outline of the proposed system

As illustrated in Fig. 1, the suggested system is made up of three primary blocks. Instruments such as a temperature detector, a blood pressure detector, an ECG detector, and a detector for the pulse rate collecting patient information. One block of the Raspberry Pi model includes built-in wireless connectivity, and no additional Wi-Fi module is required. This side collects data and sends it to the IoT server. The total system's data is stored on the IoT server. That data inaccessible to doctors, who can use it to obtain patient information and write appropriate prescriptions.

5. INITIAL STUDY OF PROPOSED SYSTEM

This proposed system, indicates that if the value of the sensor is higher than the value, a notification will be sent via the user application to the physician and the caregiver, and the physician and caregiver is even sending an alert message. The value is entered in the database using the Raspberry pi if the sensor result is below the predefined threshold; the data can be retrieved through the user application by logging in with the user authentication by the doctor or the patient. The doctor will be able to write the prescription by going through the data and make changes if necessary. The software tools that will be used are RASPBIAN OS, Python language, embedded c language and Wiring-Pi. This will help us in interacting with the Raspberry Pi, getting the data stored in the database and sending alert messages to the doctor as well as the caretaker.

5.1 Block Diagram

Fig. 3 shows an outline of the system itself with the connection of temperature sensor, blood pressure senor and heartbeat sensor. This is connected to the raspberry pi the output is shown in the LCD display. All the sensor values are stored in the database through the internet. The doctor and the patient can retrieve this information through a duster authentication. The cloud storage is built in that store all the information of the sensor values.

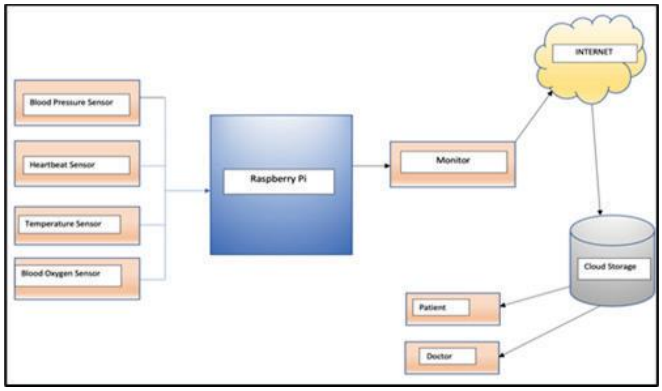

Fig. 3. Smart Healthcare Device Block Diagram

5.2 Circuit Diagram

The circuit diagram was adopted in [6]. It shows an outline of the system itself with the connection of temperature sensor, blood pressure senor and heartbeat sensor. This is connected to the raspberry pi. The output is shown in the LCD display. All the sensor values are stored in the database through the internet. The doctor and the patient can retrieve this information through an dusterauthentication. The cloud storage is built in that stores all the information of the sensor values.

5.3 Cloud Computing

Fig. 5 shows the cloud storage works with microcontroller. Firstly, all the data is collected from the sensor values then processed into the raspberry pi microcontroller. Then, this microcontroller sends signal via wireless transceivers into the computer. The raspberry pi can be connected to the internet directly. All the data is stored in the computer. The patient and the doctor can access in information through the GSM (Global System for Mobile Communications) signal. The GSM MODEM(Modulator-Demodulator) sends the GSM signal to the doctor and the patient.

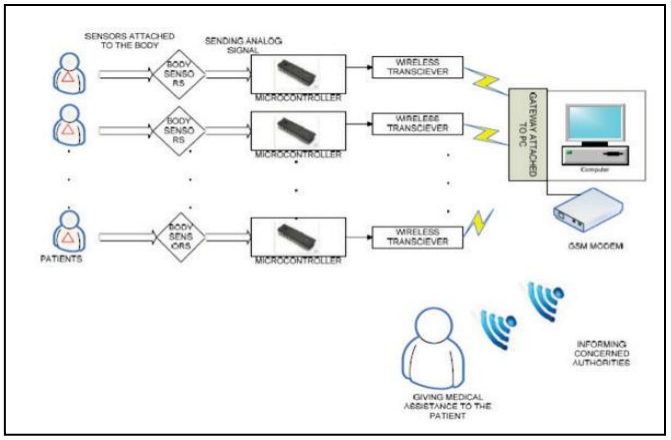

Fig. 4. Cloud Computing in Smart Healthcare Device

6. DISCUSSION

This system monitors the patient's temperature, blood pressure and pulse rate. To the Raspberry Pi, there is Serial Communication, where the Raspberry pi links the sensor data with the database. The simple functioning steps of an IoT application collecting data, processing data, storing data, and transferring data are all steps in the data collection process. All the information is kept in a database and shown on an LCD panel. The Raspberry Pi retrieves the sequential information. The Microcontroller Board was also used to capture all the data. The is unique identification for every user like the doctor and the patient. Likewise, the doctor can retrieve the information and write the prescription through the user application. The Raspberry Pi module holds the results of patient's information processing as well as object tracking reports. This module is responsible for storing and transmitting patient information to mobile or smartphone devices.

7. CONCLUSION

This paper describes a proposal of smart healthcare system and its benefits the people. This gives a summary on how the smart health device works. It gives a descriptive analysis of the system and how it makes life easier of the different kinds of patient. This system saves time for the patient as well as the doctor. The doctor can write a prescription to the patient from anywhere around the world through a user application. This system enhances the healthcare system from various ways. Thus, this paper gives a description about the IoT based health monitoring system using Raspberry Pi.

ACKNOWLEDGEMENT

The work was funded by the Department of Computer Science and Engineering at Manipal International University in Negeri Sembilan, Malaysia. This project is supported by Advance Computer Engineering and Technology (ACET) Research Group, MIU.

REFERENCES

[1] Md. M. Islam, A. Rahaman, and Md. R. Islam, 'Development of Smart Healthcare Monitoring System in IoT Environment', *SN Comput. Sci.*, vol. 1, no. 3, p. 185, May 2020, doi: 10.1007/s42979-020-00195-y.

[2] M. Mathivanan, M. Balamurugan, H. L., Nandini, and M. Reddy, 'IoT based continuous monitoring of cardiac patients using Raspberry Pi', Karnataka, India, 2018, p. 020025. doi: 10.1063/1.5078984.

[3] R. Vithiya, S. Karthika, and G. Sharmila, 'Detection, Monitoring and Tracking Of Survivors under Critical Condition Using Raspberry-Pi', in *2019 IEEE International Conference on System, Computation, Automation and Networking (ICSCAN)*, Pondicherry, India, Mar. 2019, pp. 1–5. doi: 10.1109/ICSCAN.2019.8878711

[4] Mohd. Hamim, S. Paul, S. I. Hoque, Md. N. Rahman, and I.-A. Baqee, 'IoT Based Remote Health Monitoring System for Patients and Elderly People', in *2019 International Conference on Robotics,Electrical and Signal Processing Techniques (ICREST)*, Dhaka, Bangladesh, Jan. 2019, pp. 533–538. doi: 10.1109/ICREST.2019.8644514.

[5] R. S. Nair *et al.*, 'Recent Trends and Opportunities of Remote Multi-Parameter PMS using IoT', in *2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT)*, Surabaya, Indonesia, Apr. 2021, pp. 325–329. doi: 10.1109/EIConCIT50028.2021.9431926.

[6] A. A. Zainuddin *et al.*, 'Patient Monitoring System using Computer Vision for Emotional Recognition and Vital Signs Detection', in *2020 IEEE Student Conference on Research and Development (SCOReD)*, Batu Pahat, Malaysia, Sep. 2020, pp. 22–27. doi: 10.1109/SCOReD50371.2020.9250950.

[7] K. Jaiswal, S. Sobhanayak, B. K. Mohanta, and D. Jena, 'IoT-cloud based framework for patient's data collection in smart healthcare system using raspberry-pi', in *2017 International Conference on Electrical and Computing Technologies and Applications (ICECTA)*, Ras Al Khaimah, Nov. 2017, pp. 1–4. doi: 10.1109/ICECTA.2017.8251967.

[8] Nair, R. S., Lawrence, J. M., Vyakaranam, A., Svpk, S. D., Shameem, S. S. S., Sulo, R., ... & Mansor, A. F. (2021, April). Recent Trends and Opportunities of Remote Multi-Parameter PMS using IoT. In 2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT) (pp. 325-329). IEEE.

[9] Zainuddin, A. A., Superamaniam, S., Andrew, A. C., Muraleedharan, R., Rakshys, J., Miriam, J., ... & Taufik, M. S. M. (2020, September). Patient monitoring system using computer vision for emotional recognition and vital signs detection. In 2020 IEEE Student Conference on Research and Development (SCOReD) (pp. 22-27). IEEE.

[10] S. Yattinahalli and R. M. Savithramma, 'A Personal Healthcare IoT System model using Raspberry Pi 3', in *2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT)*, Coimbatore, Apr. 2018, pp. 569–573. doi: 10.1109/ICICCT.2018.8473184.

[11] R. Kumar and M. P. Rajasekaran, 'An IoT based patient monitoring system using raspberry Pi', in *2016 International Conference on Computing Technologies and Intelligent Data Engineering (ICCTIDE'16)*, Kovilpatti, India, Jan. 2016, pp. 1–4. doi: 10.1109/ICCTIDE.2016.7725378.

[12] K. S. Naik and E. Sudarshan, 'Smart Healthcare Monitoring System Using Raspberry Pi on IOT Platform', vol. 14, no. 4, p. 5, 2019.

[13] M. G. M. Prabha, 'AUTOMATIC HEALTH MONITORING SYSTEM USING RASPBERRY PI', p. 8.

[14] C. K. R. Kirankumar and M. Prabhakaran, 'Design and implementation of low cost web based human health monitoring system using Raspberry Pi 2', in *2017 IEEE International Conference on Electrical, Instrumentation and Communication Engineering (ICEICE)*, Karur, Apr.2017, pp. 1–5. doi: 10.1109/ICEICE.2017.8191881.

[15] M. A. Muqeet and M. U. Quadri, 'IoT based Patient Monitoring System Using Raspberry Pi', vol. 7, no. 2, p. 6, 2019

[16] M. A. Saip and A. S. Mohamed, 'Smart Health Monitoring and Controlling using Raspberry Pi3', *Int. Innov. Res. J. Eng. Technol.*, vol. 4, no. 1, pp. 24–28, Sep. 2018, doi: 10.32595/iirjet.org/v4i1.2018.70.

[17] Z. U. Ahmed, M. G. Mortuza, M. J. Uddin, Md. H. Kabir, Md. Mahiuddin, and MD. J. Hoque, 'Internet of Things Based Patient Health Monitoring System Using Wearable Biomedical Device', in *2018 International Conference on Innovation in Engineering and Technology (ICIET)*, Dhaka, Bangladesh, Dec. 2018, pp. 1–5. doi: 10.1109/CIET.2018.8660846.

[18] E. N. Ganesh, 'Health Monitoring System using Raspberry Pi and IOT', *Orient. J. Comput. Sci. Technol.*, vol. 12, no. 1, pp. 08–13, Apr. 2019, doi: 10.13005/ojcst12.01.03.

[19] S. B. Baker, W. Xiang, and I. Atkinson, 'Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities', *IEEE Access*, vol. 5, pp. 26521–26544, 2017, doi: 10.1109/ACCESS.2017.2775180.

[20] S. Selvaraj and S. Sundaravaradhan, 'Challenges and opportunities in IoT healthcare systems: a systematic review', *SN Appl. Sci.*, vol. 2, no. 1, p. 139, Jan. 2020, doi: 10.1007/s42452-019-1925-y.