EVOLUTION IN ELECTRICAL AND ELECTRONIC ENGINEERING
e-ISSN: 2756-8458

EEEE

Vol. 5 No. 1 (2024) 504-511
https://publisher.uthm.edu.my/periodicals/index.php/eeee

Internet of Things (IoT) Based Health Telemonitoring System

Sutharson Sugumaran[1], Rahmat Sanudin[1]*

[1] *Faculty of Electrical and Electronic Engineering*
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Johor, MALAYSIA

*Corresponding Author: rahmats@uthm.edu.my
DOI: https://doi.org/10.30880/eeee.2024.05.01.063

Article Info

Received: 10 January 2024
Accepted: 16 March 2024
Available online: 30 April 2024

Keywords

Health telemonitoring system, Health Condition, Heart rate sensor, Temperature sensor, Wearable medical devices, Internet of things (IoT)

Abstract

The purpose of this work is to develop an Internet of Things (IoT)-based health telemonitoring system. IoT is an excellent method to reduce human effort and provide simple access to physical objects. With this technology, people could utilise wireless connections everywhere they go. In modern days, people do not have enough time to keep track of their health status because of their busy lifestyle. Therefore, a health monitoring system that follows users automatically is proposed in this work. This system uses an Arduino Uno R3 microcontroller integrated with suitable sensors to monitor their health parameters. The health data being collected by the prototype are heart rate, body temperature, and blood saturation level, as well as the health condition of a patient, in real time. In addition, Blynk application is utilised to store collected data in cloud platform. Results from this prototype shows that the the data could be collected consistently. The health data could be monitored, recorded, and stored in a database. The prototype showcases an effective utilisation of IoT in healthcare application, especially for elderly people in the future.

1. Introduction

Ischemic heart disease remained the highest cause of death in Malaysia, accounting for 18.0% of the 109,155 deaths that were medically proven in 2020, according to the Department of Statistics (Akmal et al, 2020). Everyone is at risk of developing heart disease. Therefore, consider managing modifiable risk factors such as alcohol, smoking, physical inactivity, poor diet, diabetes, high blood pressure, and diseases such as high cholesterol levels. Nonmodifiable risk factors are age, family history, and ethnicity (Lum, 2018). A huge number of adults and the elderly can develop heart disease, but an unhealthy lifestyle also becomes a factor in heart disease among children and young adults. A person who has a heart disease may collapse anytime in public or while driving, which is a risk for them. The worst case is when a heart disease patient dies without any symptoms. Additionally, patients with medical issues such as high cholesterol, high blood pressure, and obesity (WHO, 2013) are at increased risk of developing heart disease, so special attention should be paid to their hearts.

Nowadays, with the development and rapid improvement of the internet, technology such as the IoT has emerged and is exploding (Kioumars et al, 2011). IoT refers to connections to physical devices and the internet around the world. There are a lot of other IoT-based applications, like smart homes, (Wan et al, 2018) which were created to demonstrate that a house is "smart" enough to control its "daily home operation." This implies interfacing home machines like home security frameworks and cameras, sound recordings, and others, and simultaneously empowering the users to control their activities from a distance utilizing gadgets like cell telephones and PC's (Zhao, 2021).

Precisely, IoT has recently been applied in healthcare. Both hospitals and individual health care are currently using IoT technologies. A health telemonitoring system that uses sensors to assess patients' heart rates and body temperatures and display the data in real-time is possible thanks to the IoT (Kunal et al, 2022). In this thesis, an IoT-based health telemonitoring system is proposed, where people may obtain their health information online, sensing data, and begin tracking their health status automatically rather than having to visit clinics or hospitals for various tests. The sensing parameters obtained will be used to observe and collect the data that will be sent through a wireless connection. By utilizing open-source services like mobile applications, IoT, which realizes the link between devices, makes it possible for actions like sending an alert email and texts during an emergency situation. Providing continuous health monitoring is important to save their lives whenever their health conditions need medical attention and potentially to reduce the risk of a sudden death due to late attendance by the patient (Saranya et al, 2018). The main idea of this work is to use the Internet of Things (IoT) platform to provide better and smarter services in the Industrial Revolution 4.0 (IR4.0) era, especially in healthcare (Paul et al, 2021)(Bohora et al., 2016). In regard to smart systems, the objective is to develop some of the following factors, such power usage, reliability, and improved performance, which gather information on the body and send parameters through wireless technology (Parihar, 2019)(Mahgoub et al., 2015).

2. Materials and Methods

In this section, there are 2 stages that lead to the work's success by acknowledging each software and hardware function.

2.1 Block Diagram

A block diagram is illustrated to aid in the most basic understanding of the system's software and hardware implementation. The relationship between input, process, and output is represented by the block and arrow. Fig. 1 shows the block diagram of the Internet of Things (IoT)-based health telemonitoring system. The diagram shows that the sensor is used as the input, the Arduino Uno R3 [11] board is the processing unit, and finally for the output displays through the LCD display and Blynk application. The Max30100 and LM35 temperature sensors [12] are the input tools for monitoring patient health parameters. The Arduino Uno R3 is the component of the system that is used to transfer the data output. The Arduino IDE is used to program the input and to evaluate the output value. The LCD display and Blynk application are the output devices, and they show the collected parameters of a patient's heart rate, blood saturation level, and body temperature through the smartphone.

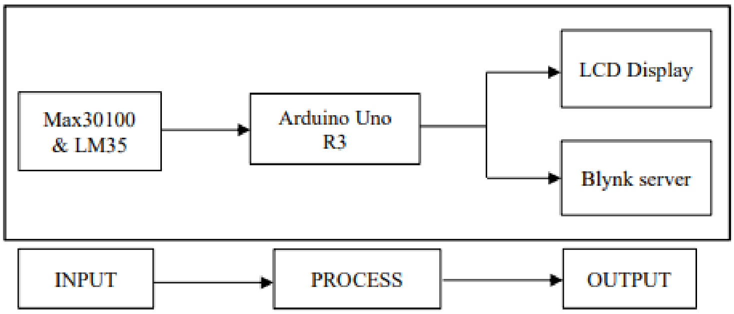

Fig. 1 *Block diagram of health telemonitoring system*

2.2 Methodology

This system consists of the MAX30100 and LM35 temperatures, which will detect the health data of a patient. This system will be controlled by an Arduino Uno R3 to transmit data and display the parameter through mobile applications. The data acquired or the flowchart is shown in Fig. 2. The purpose of this flow chart is to give an overview of the steps for this system automatically.

2.3 Circuit Diagram

All the sensors connection is combined in this circuit diagram as shown in Fig. 3.

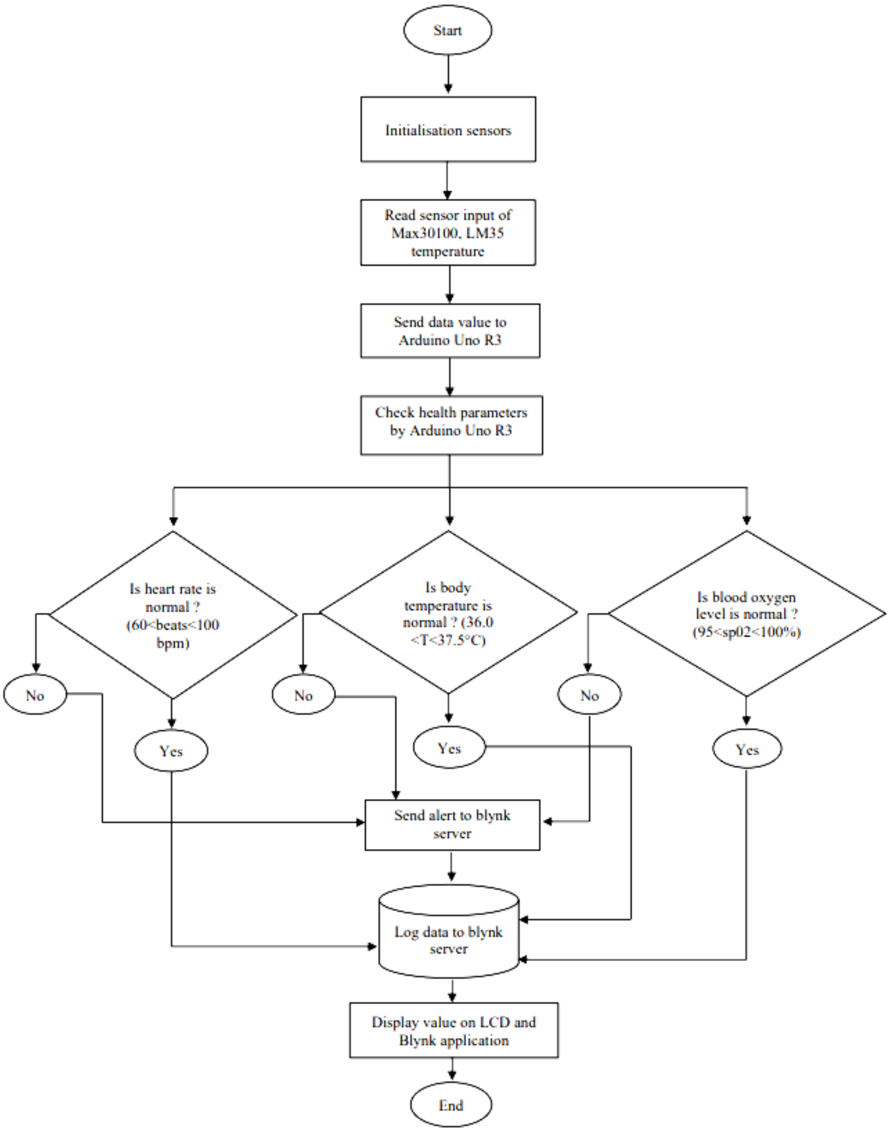

Fig. 2 *Process flowchart of health telemonitoring system*

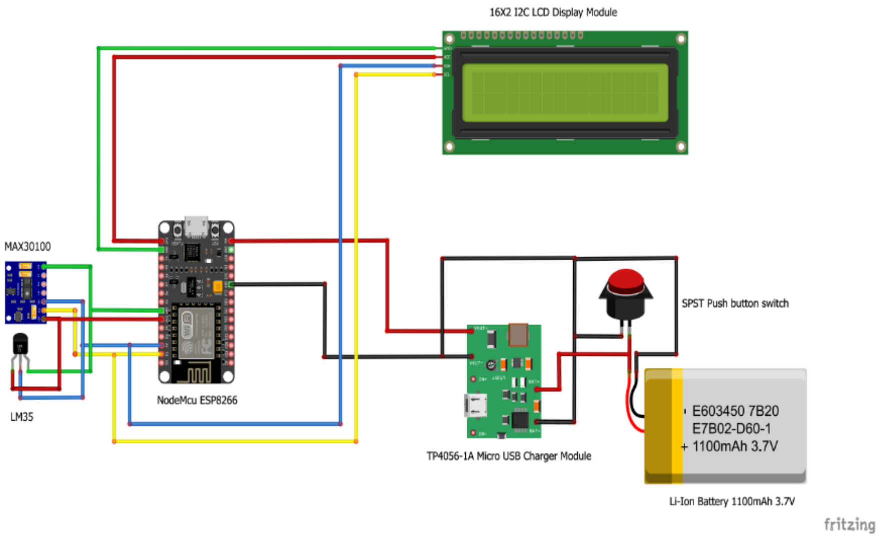

Fig. 3 *Circuit diagram of health telemonitoring system*

3. Result and Discussion

3.1 Characterization of GNBPs

This device is operated by a 3.7-volt lipo battery and functions by switching the ON/OFF button. Firstly, the user should wear the finger splint wrist band. When the button is pressed, the device will turn ON and the Wi-Fi will automatically connect to the device. Then, the user should place their finger on the heart rate and body temperature sensors to start measuring the heart rate, blood oxygen level, and body temperature before the information is sent to the Blynk cloud server. Next, the Blynk application will start operating and the health parameters will appear on the display that is attached to the device. The Blynk app also enables the user to browse the data on their smartphone. In order to notify the user and caregiver, the notification feature was also implemented in the system via the Blynk app. It is triggered with a notification when an abnormal heart rate is identified. The dimensions of this portable health telemonitoring device are 8.9cm (L) x 6.2cm (W) x 4.5cm (H) and it is convenient to wear, as shown in Fig. 4.

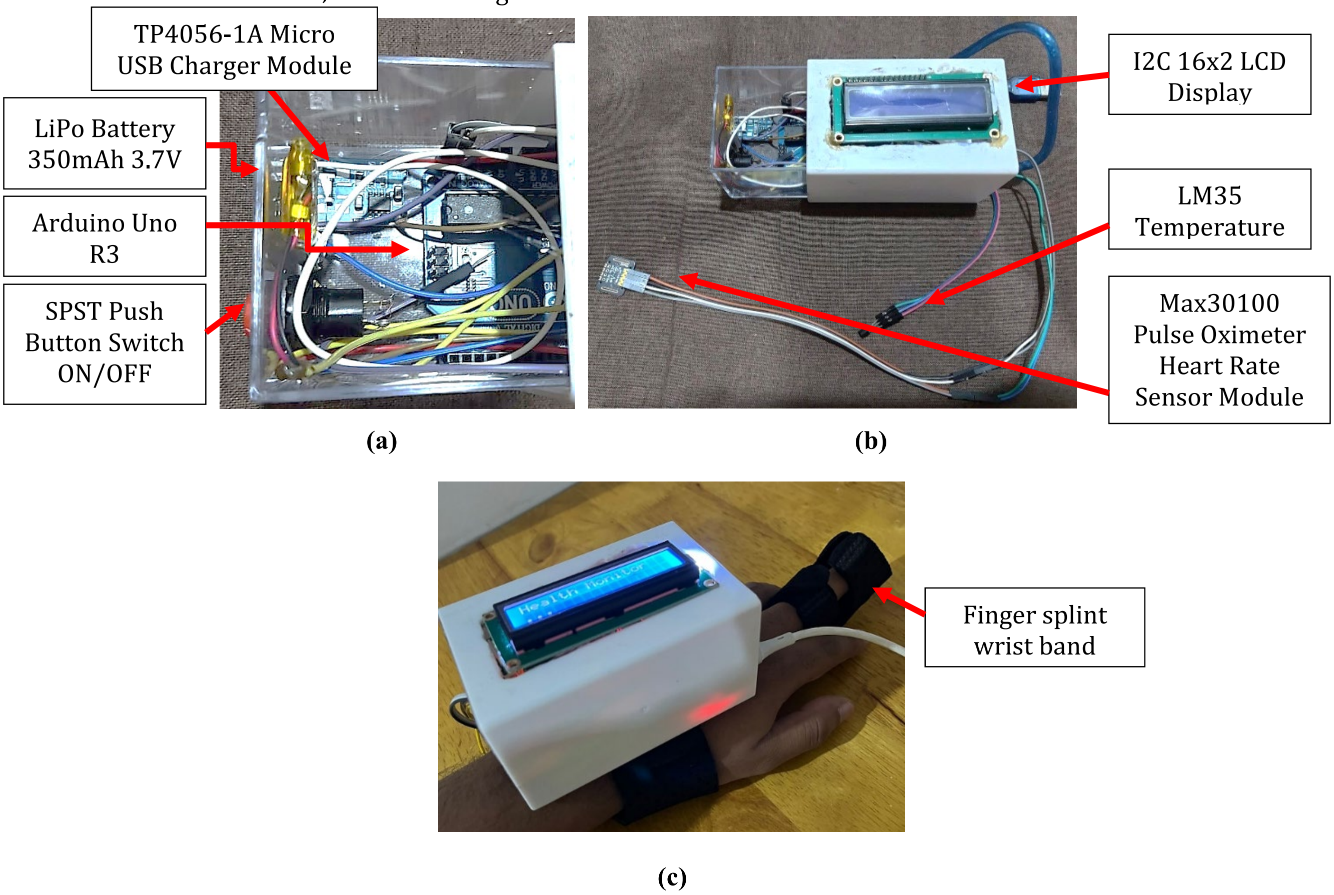

Fig. 4 *Prototype of health telemonitoring system*

3.2 Power Consumption

The power consumption of the system used a 3V battery to power it, which can last around 2 hours. Then, a charger module was also added to the system to charge the battery, and it will take around 2 hours for the battery to be fully charged.

3.3 Collected Data

The health telemonitoring system developed is tested on various people with normal to abnormal health conditions. The various tests and findings producing results, along with the status and the observations are listed in Fig. 5, Table 1, Table 2 and Table 3, respectively.

(a)

(b)

Fig. 5 *Observed heart rate, sp02 and temperature reading from (a) person 1 (b) person 2*

Table 1 *Observed temperature readings*

Testing	Normal value	Observed value	Status
Person 1	36.0°C to 37.5°C	37.17°C	Normal
Person 2	36.0°C to 37.5°C	36.68°C	Normal

Table 2 *Observed heart rate readings*

Testing	Normal value	Observed value	Status
Person 1	60-100	71 bpm	Normal
Person 2	60-100	62 bpm	Normal

Table 3 *Observed sp02 readings*

Testing	Normal value	Observed value	Status
Person 1	95-100	95 %	Normal
Person 2	95-100	95 %	Normal

3.4 Cloud Platform

The Blynk platform or domain will be used to construct the IoT application shown in Fig. 6. The profile was created in the Blynk application by using a PC shown in Fig. 7 and Fig. 8. This IoT application is designed and developed to monitor and control the sensor readings of bpm, sp02 and body temperature shown in Fig. 9 to Fig. 11. There is limited accessibility for the Blynk application, where only two users can access it at the same time using the same email and password.

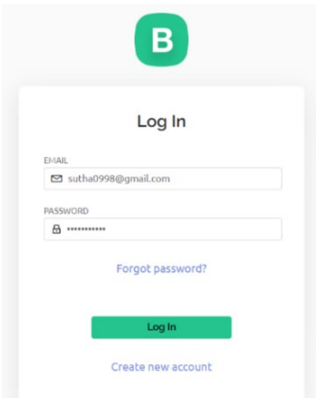

Fig. 6 *Login with the assigned user account*

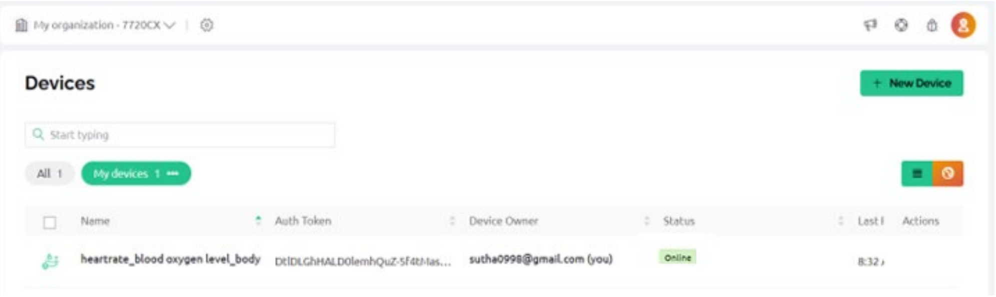

Fig. 7 *Assigned user with access*

Fig. 8 *Dashboard showing health data*

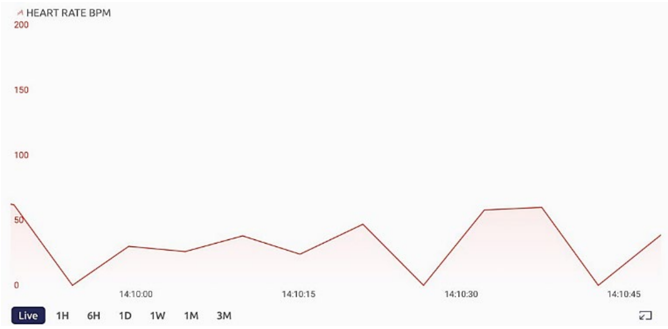

Fig. 9 *Real-time chart for heart rate from Blynk*

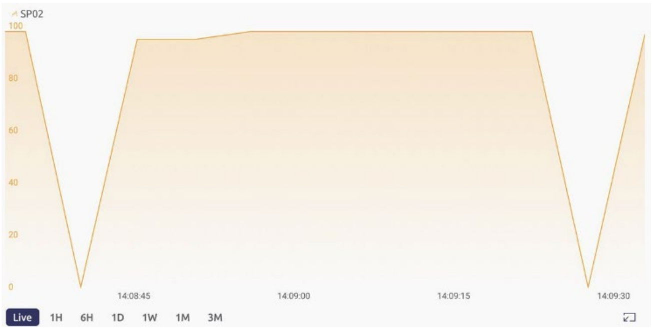

Fig. 10 *Real-time chart for sp02 from Blynk*

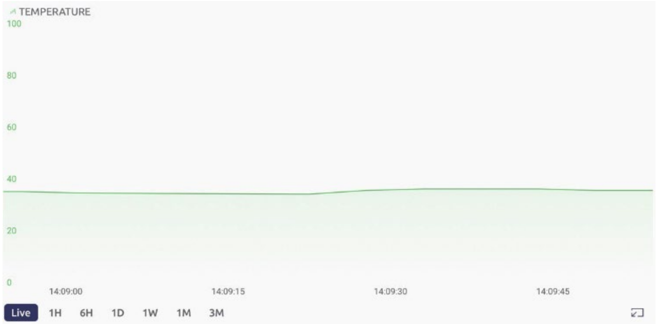

Fig. 11 *Real-time chart for body temperature from Blynk*

Fig. 12 shows the results of the abnormal value of the system from the Arduino application on Blynk. When the heart rate value is more than 100 bpm, the sp02 value is less than 95%, and the body temperature value is more than 38 °C, then the system will receive the notification from Blynk.

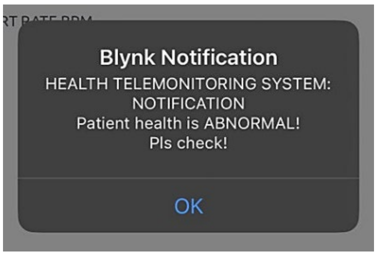

Fig. 12 *Results of abnormal value*

3.5 Data Analysis

The health data collected by the system is displayed and updated on the Blynk application in real time, as shown in the Figure above. The data displayed are the heart rate is 86 bpm, which is taken from the Max 30100 sensor to represent the red gauge meter, the blood saturation level is 98%, which is taken from the Max 30100 sensor to represent the orange gauge meter and the body temperature level is 37 °C, which is taken from the LM 35 temperature sensor to represent the green gauge meter of the user. The given gauge meters can collect the readings "live," or in real time.

A super chart was also added for monitoring purposes. It is helpful and easy for the user to monitor the surrounding parameters. Heart rate is usually referred to BPM (beats per minute), which means the number of heartbeats in one minute and is often used to measure and monitor heart rate. BPM is calculated by taking a person's number of beats in a 15 seconds period and multiplying by 4 to get the number of beats in the entire period. The SpO2 (peripheral capillary oxygen saturation) measured by a photodetector on the sensor measures the intensity of the transmitted or reflected light after it has passed through the skin and it is calculated using the ratio of oxygenated and deoxygenated hemoglobin in the blood. The reading of the measurement will be shown in percentages (%). The MAX30100 sensor has four pins been used, which are input, scl, sda and ground. The input will connect to 3 volts, the scl and sda will connect to A4 and A5, and the ground will connect to the ground of the Arduino Uno. Then, the LM35 temperature sensor has three pins which are input, output and ground. The input pin is connected to 4-20V, the output pin is connected to AO and the ground pin is connected to the ground of the Arduino Uno. It converts the analog reading, which goes from 0 to 1023 to a voltage of 0 to 5 volts when referring to coding. Then, it will multiply by (5000 / 1024.0).

Lastly, the designed device will notify the caregiver of abnormal heart rate detection and body temperature and upload data to the Blynk cloud service. The user's smartphone can be used to access the data through the Blynk app, and they can self-monitor by keeping track of changes in health parameters. The data on the patient's health parameters will be stored in the cloud. Therefore, it has greater advantages than keeping records on paper documents stored in files. Also, recording data on a digital device like a smartphone or laptop can get corrupted and data might be lost. Whereas, in the world of IoT, cloud storage is more dependable and has fewer possibilities of data loss.

4. Conclusion

In conclusion, this work was successful in developing the concept of an IoT-based health telemonitoring system that was integrated with an Android mobile application. The objective has been successfully achieved which is to design and build a real-time an IoT-based health telemonitoring system. The proposed system is able to monitor the user's heart rate, blood saturation level, and body temperature and notify them when they are abnormal. Since the system is in a wearable prototype stage, its accuracy has been recognized as suitable and sufficient for remote monitoring when compared to devices that exist commercially.

Acknowledgement

The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***project design and data analysis:*** *Sutharson Sugumaran;* ***data and draft manuscript verification:*** *Rahmat Sanudin. All authors reviewed the results and approved the final version of the manuscript.*

References

Akmal Alekya R., Boddeti N.D., Monica K.S., Prabha R., Venkatesh V. (2020). IoT based smart healthcare monitoring systems using sensors: A literature review. Eur. J. Mol. Clin. Med. 2021;7.

Bohora, B., Maharjan, S. and Shrestha, B.R., (2016). IoT-Based Smart Wireless Health Monitor System Using Blynk Framework. Zerone Scholar, 1(1), pp. 26-30.

H. Zhao, P.-L. Chen, S. Khan, and O. I. Khalafe, (2021). "Research on the optimization of the management process on internet of things (Iot) for electronic market," The Electronic Library, vol. 39, no. 4, pp. 526–538.

J. Wan, M. A. A. H. Al-awlaqi, M. S. Li, M. O. Grady, and X. Gu, (2018) "Wearable IoT enabled real-time health monitoring system," EURASIP Journal on Wireless Communications and Networking, vol. 298, pp. 1–10.

Kioumars A.H., Tang L. Wireless network for health monitoring: heart rate and temperature sensor 2011 Fifth International Conference on Sensing Technology (2011), pp. 362-369, 10.1109/ICSensT.2011.6137000.

Kunal D. Gaikwad, Poonam U Gadgil, Kamlesh V Chandekar, (2022). "A Low Cost Health Monitoring System by Maintaining Health Protocol", 2022 6th International Conference on Trends in Electronics and Informatics (ICOEI), pp.1715-1721.

M. Lum. (2018). Why cardiovascular disease is the leading cause of death in Malaysia and the reason. [Online]Available: https://www.star2.com/health/2018/03/12/too-muchtoo-little-toofat/.

M. Saranya, R. Preethi, M. Rupasriand, and S. Veena, "A survey on health monitoring system by using IOT," (2018). International Journal for Research in Applied Science and Engineering Technology, vol. 6, no. 3, pp. 778–782.

M. T. A. Mahgoub, O. O. Khalifa, K. A. Sidek, and S. Khan, "Health monitoring system using Pulse Oximeter and LM35 with remote alert," Proc. - 2015 Int. Conf. Comput. Control. Networking, Electron. Embed. Syst. Eng. ICCNEEE 2015, pp. 357–361, 2016, doi: 10.1109/ICCNEEE.2015.7381391.

Parihar, Y. S. (2019). Internet of Things and Arduino. Journal of Emerging Technologies and Innovative Research,6(6), 1085.

S. Paul, M. Riffat, A. Yasir, M.N. Mahim, B.Y. Sharnali, I.T. Naheen, A. Rahman, A. Kulkarni Industry 4.0 Electronic Applications for Medical/Healthcare Services Journal of Sensor and Wireless Networks, 10 (3) (2021), p. 43, 10.3390/jsan10030043.

World Health Organization (2013). Malaysia: Health profile. Retrieved August 5, 2013, from http://www.who.intnmh countries mys en.pdf.