IOT-BASED COVID-19 PATIENT MONITORING SYSTEM

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INTRODUCTION

Covid -19 is a global pandemic that has created problems in peoples' day-to-day lives, regardless of nationality, gender, religion, colour, poverty and wealth. According to the WHO, over 4.15 million people have lost their lives during this global pandemic, while over 190 million cases have been reported worldwide. Nowadays people are removing their masks and restarting their usual lifestyles. Vaccination has led to an increase in immunity to the virus, but the risk has regenerated with the new variants of the virus such as delta and omicron. Such variants are riskier and spread more widely. Due to the increase of Covid-19 patients in the country, patients are kept in their homes. The main problem with this scenario is the unavailability of a proper method to monitor the patients at home.

Patients need more attention from physicians because death percentages due to the new variants are higher than previous versions. Treatment centres in some countries are fully occupied. So, a large number of patients are treated under home quarantine. Even though they need physicians' protection and instructions, it may not be available most of the time because of the limitation of the capacity of physicians to physically reach patients. To solve these practical issues, an Internet of Things (IoT)-based Covid-19 Patient Monitoring System was suggested. The body temperature, blood oxygen saturation, and pulse rate of patients are monitored by this system. They are the most common parameters of Covid-19 patients (al Bassam et al., 2021).

IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers with the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Gillis, 2022). IoT and health technologies may revolutionize the healthcare industry over the next decade and thus significantly impact the healthcare system (Kelly et al., 2020). IoT is the most suitable method to use for these types of systems because it can avoid the spreading of the disease from patient to physician. In addition, non-critical patients can spend their quarantine period at home which makes patients feel positive while allowing more critical patients to get professional care at quarantine centres or hospitals. This research project aims to implement a system for home quarantined Covid-19 patients to monitor their primary health parameters and maintain good health by remotely recognizing critical moments. To achieve this aim, a wearable device was designed and fabricated to measure the body temperature, oxygen saturation level, and pulse rate of its wearer. Moreover, an android application was developed to change the Service Set Identifier (SSID) and password of the wearable device to connect to any Wireless Fidelity (Wi-Fi) connection, as per users' preferences, without hard coding. A dashboard was also designed to monitor the Covid-19 patient remotely.

METHODOLOGY

In this research, a wearable device has been designed that can measure the body temperature, blood oxygen saturation, and pulse rate, the most important health parameters of a Covid-19 patient, of its wearer. The measured data is sent to a web-based system via a cloud server. The wearable device has been designed to be ergonomic as a patient must wear the device for at least seven consecutive days. The system has security protection and the monitoring of a

patient's status would need the user to log in to the system with a username and password. The system has the capability to connect with many devices which are worn by patients while many authorized people can connect to the system to access the patient's status at the same time. The system shows the real-time data of patients who wear the devices. The device also has a display, which shows each measuring parameter. So, the patient can also be aware of his/her data. Patients' data are stored as data logs once per hour in a database, which can be retrieved by an authorized person when a patient's history is needed. The system makes emergency alerts when a patient is in a critical situation. Figure 1 shows the general architecture diagram of the system.

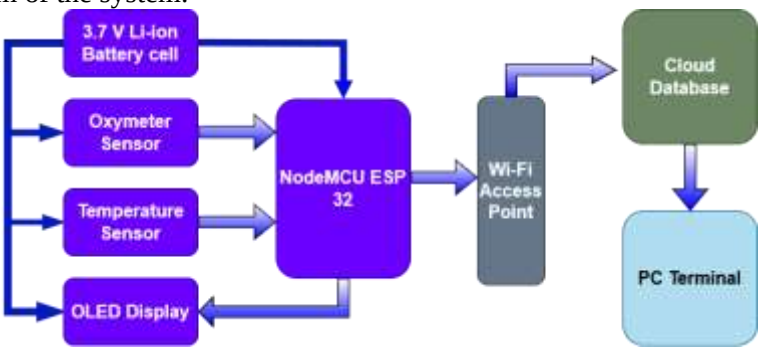
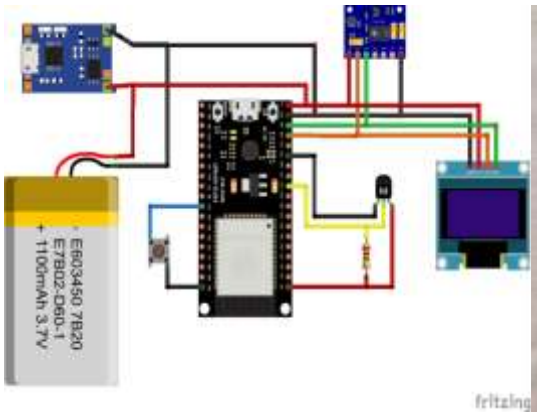


Figure 1: General system architecture diagram

Wearable Device

NodeMCU ESP 32 was applied as the microcontroller for the wearable device and it is a powerful yet cost-effective module that can work with firmware to provide Wi-Fi connectivity to external host MCUs like the Arduino or as self-sufficient programmable MCUs with an RTOS-based SDK that can run applications. NodeMCU ESP 32 also has inbuilt Bluetooth connectivity. A DS18B20 sensor is used to measure the body temperature while a MAX30100 sensor is used to measure the blood oxygen saturation and pulse rate of the patient. Sensor accuracy is the most important factor of bio-medical systems. DS18B20 has an accuracy of + or – 0.5 Celsius and MAX30100 has an accuracy of 1% for oxygen saturation. A finger clip has been used to attach the MAX30100 sensor to get more precise values. Furthermore, the selected sensors consume low power, a thereby, extending the battery life of the device. The wearable device consists of an OLED display to show the measuring parameters of the wearer. A 3.7 Volts 1000mAh lithium-ion battery was used to power the device. A TP 4056 charging module is used for charging the battery, which can charge the battery while the device is switched on. Figure 2a shows the circuit diagram of the wearable device and Figure 2b shows the image of the fabricated wearable device.



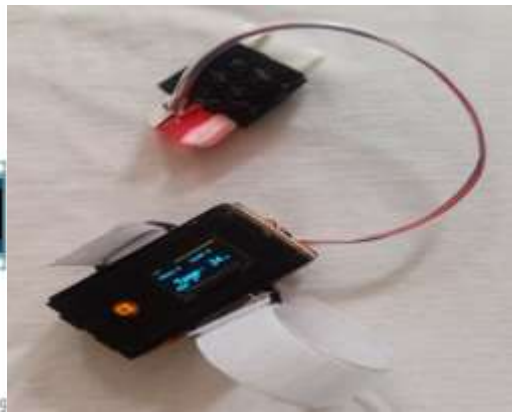


Figure 2a: Circuit diagram of wearable device

Figure 2b: The wearable device

Android application

Patients should have the option to connect their device to the internet through any Wi-Fi connection. An android application was developed for this system to change the SSID and password of the Wi-Fi connection using a Bluetooth connection. This application allows the user to manage the Wi-Fi connection used by the wearable device. Figure 3 shows the user interface of the android application.

Figure 3: User interface of Android application

Cloud database

Before communicating measured data from the wearable device to the monitoring device, data should be stored in an online database. Google Firebase was used as the online database in this research project.

Web-based Dashboard

An HTML, CSS, and JavaScript coded web application is used as a dashboard of the system. The dashboard contains web pages for particular tasks such as real-time monitoring, checking history, and registering new patients. The user has to log into the dashboard through a valid username and password before accessing patients' records.

RESULTS AND DISCUSSION

The Bluetooth mode of the device can be turned on by long-pressing the BT push-button allowing the Android application to establish a connection with the wearable device via Bluetooth. As shown in Figure 4, the wearable device and other available devices were shown on the Android screen after pressing the 'Connect To BT' button of the application. The mobile application can then be used to communicate the SSID and password of the intended Wi-Fi connection to the wearable device. The received Wi-Fi preferences are then saved into the EEPROM of the wearable device and these Wi-Fi preferences can be used to connect the device to the internet.

Figure 4: List of available Bluetooth devices as shown on the Android application

The data from the Google-Firebase database is shown on the real-time dashboard as shown in Figure 5.

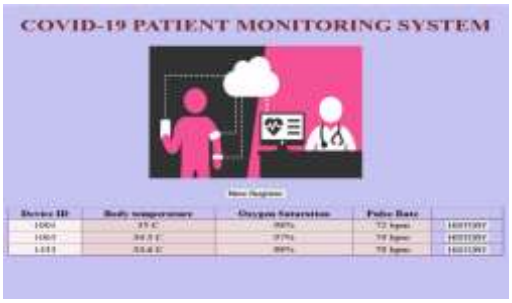


Figure 5: Realtime Dashboard

Figure 6 shows the new patient registration page of the website. As shown in Figure 7, when a new patient is registered through the form, the data gets saved on the Google Firebase database.

Figure 6: New Patient Register Interface **Figure 7:** Database

Patient history can be viewed as a table or a graph on the online dashboard. Figure 8 shows the patient history as a table while Figure 9 shows the body temperature variation of a patient over time. This data can be analyzed by authorized users to diagnose a patient's condition.

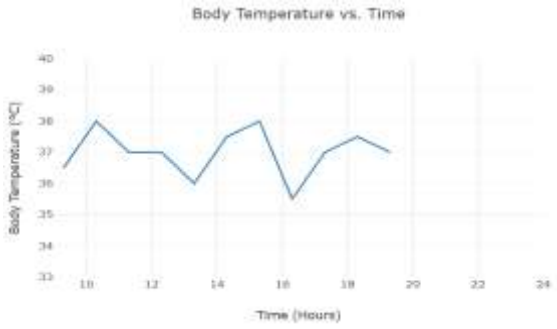


Figure 8: Patient history table **Figure 9:** Patient's History graph

CONCLUSIONS/RECOMMENDATIONS

This research designed a patient monitoring system for Covid-19 patients. The designed wearable device successfully measures the body temperature, pulse rate, and oxygen saturation of patients, and sends this data to the system via a cloud database. Then the measured data is successfully displayed on the developed web-based dashboard. In addition to measuring and displaying the health parameters, the designed system provides further options for users, such as showing the patients' history grid, analysing patients' body temperature in the last 24 hours on a graph, and displaying the measured data on an oled display attached to the wearable device. While Sri Lanka and many other countries have been able to successfully control the spread of Covid-19 through vaccination, there are still patients that require close monitoring. This device can be used effectively for this purpose. In addition to Covid-19 monitoring, the system can also be used to monitor patients suffering from fever and other respiratory diseases.

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