IOT Based Integrated COVID-19 Self-Monitoring Tool (COV-SMT) for Quarantine

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Abstract—COVID-19 Self-Monitoring Tool (COV-SMT) is the research developed to address multiple issues in monitoring quarantined individuals due to COVID-19 infection. As COVID-19 is still highly infectious despite the availability of vaccines, the implementation of contactless Internet of Things (IoT) technology should be encouraged to minimize the need for medical staff to perform daily health checks and thus prevent them from being directly infected during checking. This research aims to develop an effective method to monitor quarantined individuals regarding their vital signs, such as body temperature, heart rate, and oxygen level. A contactless self-monitoring tool integrated with a stages algorithm is developed to monitor these quarantined individuals with the help of IoT technology. It can provide a consistent platform for patients or users to transfer information or data through networks, including personalized healthcare domains. COV-SMT is an effective tool to streamlet the overall process of taking measurements from quarantined individuals. It integrates multiple sensors into one tool while providing a better overall picture with its graphical presentation to help patients and medical staff better understand their health conditions.

Keywords—COVID-19, IoT, self-monitoring tool, health

1 Introduction

The COVID-19 pandemic has raged worldwide since its discovery in late 2019. The World Health Organization (WHO) classified it as a global pandemic when the virus began to spread worldwide. As the trend of infection cases worldwide is still at a concerning level, with the number of cases per day fluctuating and increasing steadily, front liners are overwhelmed by the constant influx of patients coming in and out of the hospital. Other sectors are also affected due to shutdown requirements whenever cases are detected despite more people getting their vaccines and booster doses. People can still be infected even after their vaccination, as it is not considered a hundred percent effective method [1]. Moreover, many countries are in the transition phase from pandemic to endemic. They are looking forward to opening their international borders, which ultimately results in a more significant number of cases. Thus the rate of COVID-19 infection shall exceed the rate of recovery from the disease [2].

The Internet of Things (IoT) is a rapidly growing ecosystem that connects hardware, software, digital machines, material things, or computing devices to interact, collect, share, and exchange data [3]. It has become a staple technology in many sectors and is essential in our daily lives [15]. As the advancement of IoT continues, healthcare sectors are adopting it to provide better healthcare delivery with the Internet of Medical Things (IoMT) technology, in which medical sensors and specialized medical equipment are incorporated to revolutionize healthcare environments [4], [13]. These sensors and contactless technologies will become more relevant as the world is under a pandemic, as they reduce the need for close contact to monitor quarantined patients [5].

2 Related work

Coronavirus disease 2019 (COVID-19), is a disease caused by a type of coronavirus known as SARS-CoV-2. It was believed to be originated in Wuhan, China, upon its discovery in December 2019. Later it was declared a pandemic on 11 March 2020. According to World Health Organization, the disease has infected 609,848,852 people with 6,507,002 deaths [9].

Among the common symptoms of this disease are fever, cough, fatigue, and shortness of breath or dyspnea [7]. This disease has been highlighted by [6], which consists of four stages of infection, as shown in Table 1.

Table 1. Data Threshold for COVID-19 Stages

Data \ Stage	Normal	1	2	3	4
Body Temperature (°C)	<37	≥ 37	≥ 37	≥ 37	≥ 37
Heart Rate (bpm)	≤100	≤100	>100	>100	≥110
Oxygen Level (%)	≥96	≥96	≥96	95	≤ 94

Before the advent of IoT, all healthcare systems and applications regarding medical records documentation and patient monitoring were handled manually. As technology gradually develops and becomes an inseparable part of human life [10], IoT technology has become prevalent and vital to the healthcare sector, particularly in using medical equipment functionality, maintenance, and medical records to provide optimal care to an individual patient.

Continuous Glucose Monitoring (CGM) is an example of the invention of IoT applications in healthcare to monitor diabetes and glucose levels, as mentioned by [8].

The system specializes in remote patient monitoring and illness identification, and it can streamline the health monitoring by the patient and onsite caregiver. Implementing an IoT healthcare system may provide remote therapy for patient monitoring and disease identification. There was a significant improvement in general public health due to the implementation of IoT technology. Recent development and services of IoT technology, such as wearable devices, smartphones, and mobile healthcare, allow users to take control of their health. Self-monitoring tools are cost-effective and efficient and are generally more accessible than the standard vital signs monitoring devices found in hospitals. They are more affordable, easier to use, and allow users to understand data without proper training. Thus, this research shall propose an IoT-based integrated self-monitoring tool for quarantine, which is COVID-19 Self-Monitoring Tool (COV-SMT).

3 Proposed method

3.1 Materials

The proposed COV-SMT consists of an ESP32 microcontroller with a built-in Wi-Fi module, DS18B20 temperature sensor probe, MAX30100 heart rate and pulse oximeter sensor, 1602 LCD screen with I2C adapter, and a buzzer. This system integrates with Blynk installed in a mobile smartphone, as smartphones can run applications for various purposes [12], [14]. In addition, Blynk and ThingSpeak are also integrated with this system and are installed in a workstation.

ESP32 is chosen as the microcontroller as it has low cost, consumes low power, is integrated with Wi-Fi capabilities, and is compatible with Arduino IDE. Meanwhile, the DS18B20 temperature sensor probe is selected to obtain more accurate temperature readings. It can detect temperatures between -55°C to +125°C and can be powered using a voltage supply of 3.0 V.

In addition, the MAX30100 heart rate and pulse oximeter sensor have a high sample rate and fast data output capability while providing an accurate real-time reading of oxygen level and heart rate. The1602 LCD with an I2C adapter displays data on the device, while the alarm buzzer is used for the alarm system. COV-SMT can be powered on by a portable power supply such as a power bank or wall outlet.

3.2 Design

COV-SMT is designed to work in a local Wi-Fi network where medical personnel can monitor quarantined individuals without being close to them. Figure 1 shows the overall architecture of the system. The architecture involves the user's phone with Blynk mobile application, a host machine running as the local Blynk server and ThingSpeak, and COV-SMT. All of these devices are connected via Wi-Fi network communication technologies to facilitate the monitoring system as proposed by [11].

In Figure 1, all devices need to establish a connection via a Wi-Fi network. The ESP32 microcontroller shall receive sensor data and send collected data to the local

Blynk server via a Wi-Fi connection. The local host with the Blynk server bridges the data communication between the COV-SMT and the user's mobile phone. At the same time, the localhost server will run ThingSpeak to collect data and generate a *.csv* file. The user's mobile phone will run Blynk to receive the ESP32 board's data from the localhost Blynk server. COV-SMT will use the obtained data to perform analysis to determine the COVID-19 stage of the individual. A notification will appear in the Blynk mobile phone application, which displays the analysis results. Furthermore, Blynk can control the alarm system to remind users to take their measurements within the time setting interval. Meanwhile, Figure 2 shows the schematic diagram of COV-SMT.

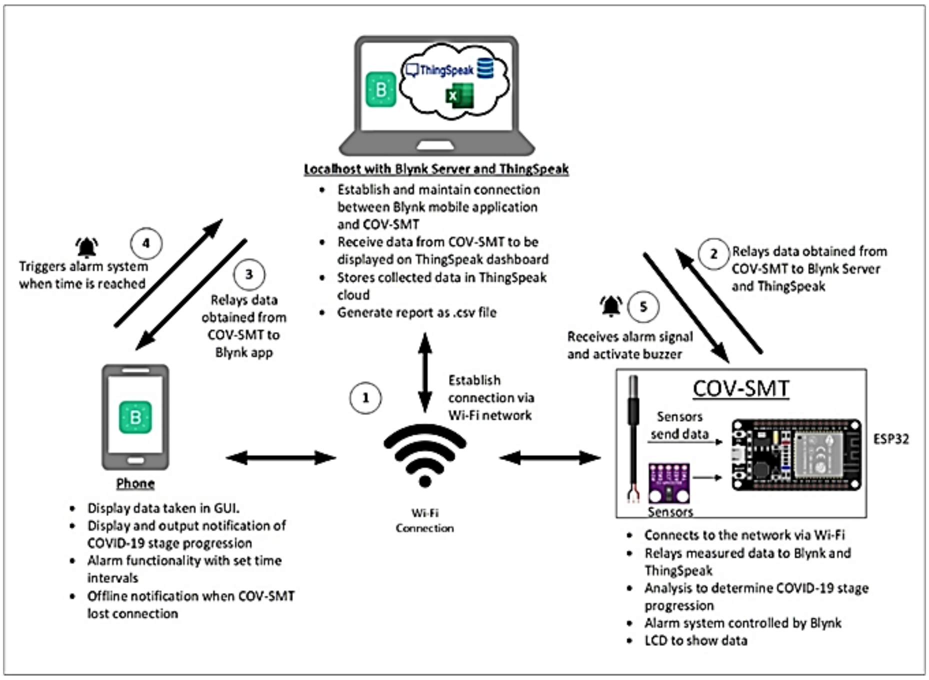

Fig. 1. Architecture Diagram of COV-SMT

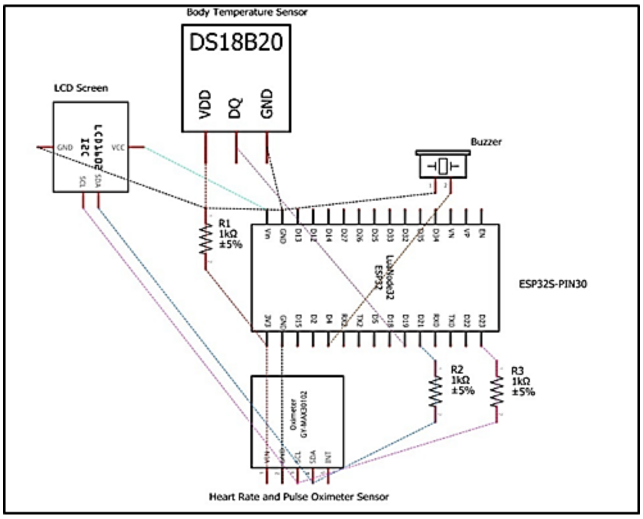

Fig. 2. Schematic Diagram of COV-SMT

3.3 Integration with Blynk and ThingSpeak

COV-SMT works along with Blynk and ThingSpeak in its implementation. The collected data is displayed on Blynk to represent data in a graphical user interface (GUI) for better interpretation in a meaningful manner. A notification will show the analysis results based on the COVID-19 stages.

At the same time, data can also be displayed on the ThingSpeak web dashboard in intuitive graphs and charts. The analysis is performed by going through a series of if/else statements which consists of five thresholds configured in COV-SMT, as shown in Table 1. If the obtained data measurements meet the conditions of the statements, the quarantined individual stage will be determined. The sample of the notification and results will then be displayed on Blynk and ThingSpeak, as shown in Figure 3 and Figure 4, respectively.

Fig. 3. Sample of Blynk Notification Displayed on Mobile phone

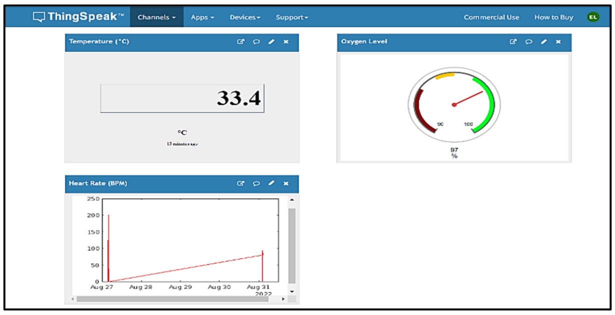

Fig. 4. Sample of Data Displayed on ThingSpeak Dashboard

4 Results and discussion

There are one normal condition and four COVID-19 stages with different thresholds to meet the output of the results. Generally, a normal person without COVID-19 will have a body temperature below 37°C, a heart rate between 40 to 100 beats per minute (bpm) at a resting state, and an oxygen level of 96% or higher. A study by [6] categorized COVID-19 into multiple stages based on its severity and symptoms. A series of trial runs were conducted to test the efficiency and accuracy of COV-SMT, and the calculated results are compared to the proposed range of measurement data.

4.1 Data analysis

For each COVID-19 stage, five trial runs are conducted to ensure that the obtained results are consistent. Using the collected data, average values are calculated to compare with the range specified in Table 1. Figure 5 shows the result obtained after the five trials measuring body temperature, heart rate, and oxygen level.

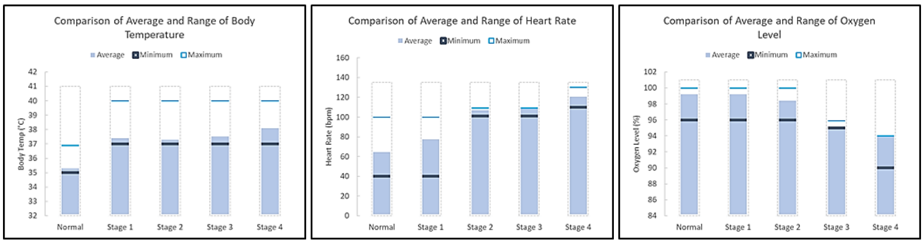

Fig. 5. Comparison of Average and Range of Body Temperature, Heart Rate and Oxygen level

The histogram graph comparing the average and range of body temperature shows that stages 1, 2, 3, and 4 have successfully and consistently recorded temperatures equal to or more than 37 °C, indicating fever. Meanwhile, the histogram graph comparing the average and range of heart rates shows that the calculated average heart rate of a normal person and stage 1's patients are in the normal range of 40 to 100 bpm. In contrast, stage 2, 3, and 4 has recorded heart rates higher than 100 bpm.

Lastly, the histogram graph of the comparison of average and range of oxygen levels shows that the measurement on normal, stages 1 and 2 are within the normal range of 96% to 100%. Stage 3 has the measurement of 95%, which is as expected as a minimum range in Table 1. In comparison, stage 4 has recorded a 94% oxygen level equivalent to the expected maximum range stated in Table 1.

These indicate that COV-SMT can accurately measure the body temperature, heart rate, and oxygen level efficiently and accurately as the average data obtained from the tests are within the range of minimum and maximum threshold of COVID-19 stages, as depicted in Table 1.

5 Conclusion

This research proposed an IoT-based self-monitoring tool for COVID-19. The finding is essential to the health-medical field as it uses IoT technology to monitor the stages of COVID-19 disease. It can streamline the overall process of taking measurements efficiently, which indirectly assists in reducing the workload of medical frontlines. It compiles and integrates various tools to monitor the quarantined individuals by measuring their body temperature, heart rate, and oxygen level effectively and accurately. The Covid-19 stages status notification is currently shown in Blynk on mobile devices; however, integrating it with well-known messaging services like WhatsApp and Telegram and a dedicated database for online data storage can further enhance this research. Additionally, there is a great chance that this instrument will be used in the health services industry.

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