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THE DEVELOPMENT OF IOT BASED PORTABLE MONITORING DEVICE FOR COVID-19 PATIENT

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Abstract

COVID-19 has posed a significant threat to public health across the world, including Malaysia. A COVID-19 patient needs to be monitored regularly and self-isolated if under home quarantined without caretakers. The unbearable number of cases has truly affected the healthcare system in managing them. To address this issue, we have developed an IOT based portable monitoring device for COVID-19 patients which is capable of measuring and recording the heart rate, oxygen saturation and electrical activity of the heart. The device comprises of a heart rate sensor, an oxygen saturation sensor (SPO2), an ECG sensor, Arduino Uno as microcontroller and an IoT server to enable the system to record the data and send it to the application which will be monitored by the end user remotely. The patient's data such as heart rate, oxygen saturation and electrical activity of the heart, all of which represent indicators of the COVID-19 virus will be measured and any abnormal readings gives the immediate alert to the end user to attend to the patient. This low-cost portable device can improve the flexibility of managing and protecting the health and safety of patients or healthcare workers while also preventing COVID-19 outbreaks.

Keywords: COVID-19 Monitoring Device, Internet of Things (IoT), Arduino UNO, ECG, Oxygen Saturation, Heart Rate.

1. Introduction

Following a December 2019 outbreak in China, the World Health Organization (WHO) identified COVID-19 as a new type of coronavirus in early 2020. Unfortunately, the virus has quickly spread throughout the world. As in Malaysia, there were two waves of COVID-19 cases and over 20,000 Malaysians have died as a result of the ongoing COVID-19 pandemic (A. Elengoe, 2020). In the middle of a pandemic, WHO issued strict guidelines to the whole world, which included staying at home, wearing a mask, washing hands frequently, social distancing, avoiding gatherings and self-isolating if develop symptoms. Thus, the Ministry of Health (MOH) distributed the national guidelines in Malaysia, as declared by the WHO, with the goal of helping front liners in every phase of COVID-19 case management (J. H. Hashim, 2021).

However, hospitals are severely affected because patients are not operated in a timely and proper manner. It can be difficult for hospitals to monitor the conditions of COVID-19 patients on a regular basis. It becomes more difficult to monitor patients' health and even healthcare worker’s safety due to a lack of supplies and the time it takes for test results (T. A. S. C. O. Post., 2020). Aside from that, due to strictly social distancing from infected people, patients who must be quarantined at home may not have caretakers who can monitor their condition. During quarantine, they can only look up to themselves before being transported to the hospital for further treatment.

Thus, the objectives of this project is to design a portable medical kit for COVID-19 patient that consists of an ECG, heart rate and SpO2 sensor. Other than that, to develop a portable medical kit that can monitor and record the condition of COVID-19 patient at home or hospital. Last but not least, to analyze the effectiveness of the portable medical kit that can integrate ECG, heart rate and oxygen saturation levels during monitoring the patient’s condition.

2. Methodology

2.1 Designing the mechanical part of the Portable Monitoring Device For Covid-19 Patient

Figure 1 shows the sketch design of the Portable Monitoring Device for COVID-19 Patients using TinkerCAD. The components of the device in this project are the Arduino Uno, NodeMCU Wi-Fi, ECG electrodes, Heart Rate SpO2 Sensor, ECG sensor, and

OLED. All the components are implemented into the storage box, which serves as a casing.

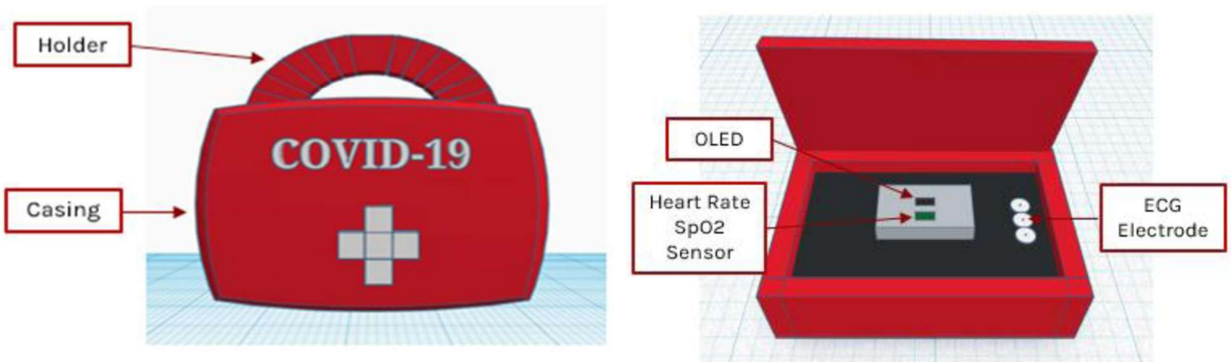

Figure 1: Design of Portable Monitoring Device For Covid-19 Patient

2.2 Developing the hardware and software implementation of the Portable Monitoring Device For Covid-19 Patient

Figure 2 illustrates the circuit installation of the Portable Monitoring Device for COVID-19 Patients. It simply depicts the assembly of all the components in the casing. The Arduino Uno and NodeMCU microcontroller programmes are loaded onto it from the Arduino IDE programming. The NodeMCU works as a development kit for prototyping and developing Internet of Things (IoT) products. In this case, IoT product used in this project is Blynk application as shown in the Figure 4. The sensors such as the MAX30100 and AD8232 are capable of recording the conditions of the user such as ECG, heart rate, and oxygen saturation (SpO2) levels, which in turn are forwarded to the microcontroller. There is also an OLED, which allows for an emissive display with high image quality. Aside from that, the circuits are connected with the jumpers to make sure that the circuits are working properly.

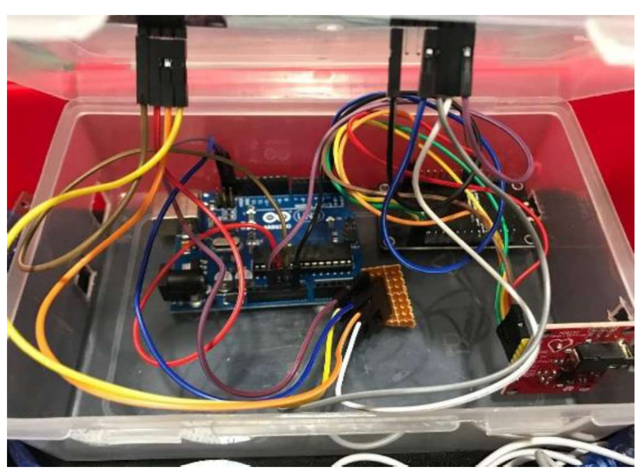

Figure 2: The circuit of the Portable Monitoring Device for Covid-19 Patient

Figure 3 shows the development of the mechanical part of Portable Monitoring Device for COVID-19 Patient. The system basically involves the collection of physiological data from the user using dedicated sensors. The system works as a whole right from the start, where the sensors record data, all the way to the very end, where the data can be seen in the specified application. To obtain the heart rate and oxygen saturation data, the patient need to attach their finger on the heart rate SpO2 sensor when the screen displayed an instruction. For ECG data, the patient just have to follow the instruction given by the manuals.

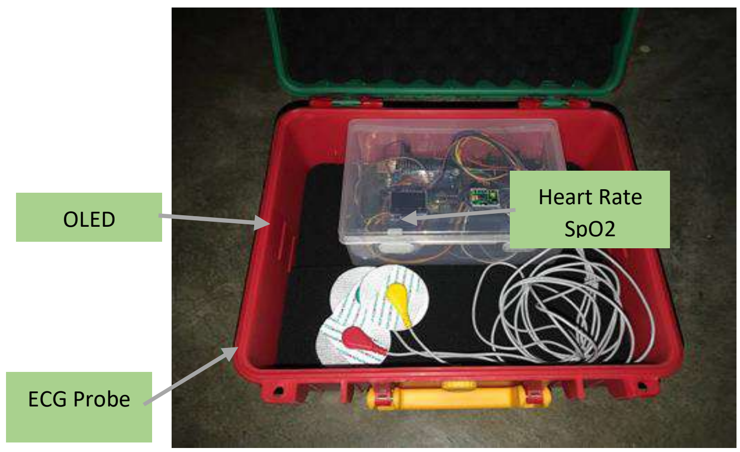

Figure 3: Portable Monitoring Device for COVID-19 Patient

Referring on Figure 4, it is an interface of an IoT implementation which known as Blynk app, shows the ECG monitoring section for a user. Users can simply download the Blynk application from the Playstore, or even access it from the Blynk website, and simply monitor their physiological condition. Overall, this device will help doctors and healthcare workers remotely monitor the condition of COVID-19 patients in real time.

Figure 4: Interface of Blynk application

2.3 Block Diagram

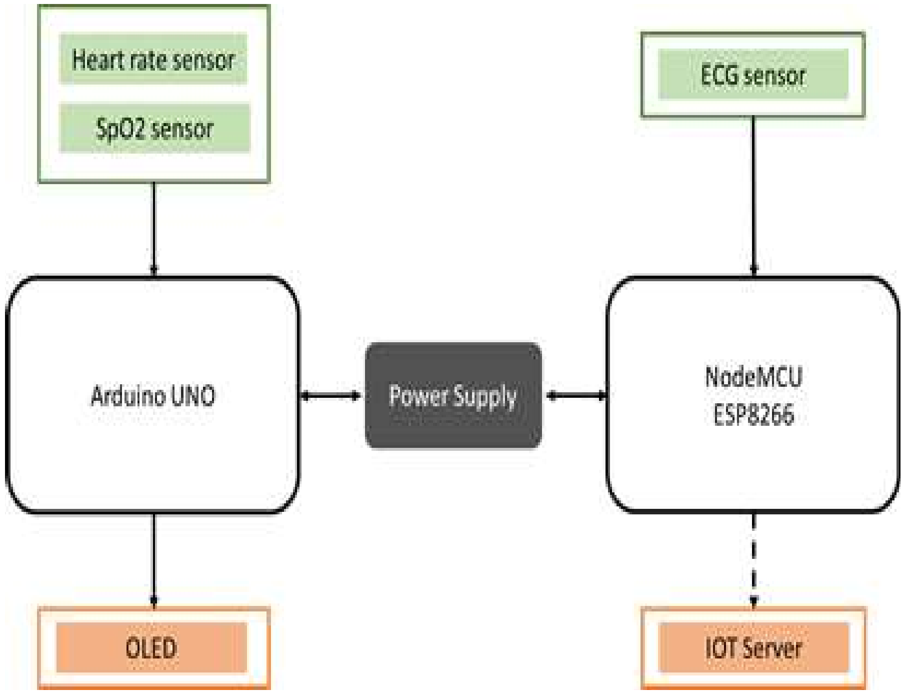

Figure 5: Block Diagram of Project

From the Figure 5 above, the block diagram shows two major roles of system's components, such as the processor, input and output. The sensor that will be used as an input is an ECG sensor, which measures the electrical activity of the heart, as well as a heart rate SpO2 sensor, which measures the beats per minute (bpm) and an oxygen saturation levels (%). The OLED display and ESP8266 Wi-Fi will be used as an output hardware. The corresponding data will be sent directly to the OLED display as well as through the computer or mobile phone.

2.4 Flow chart

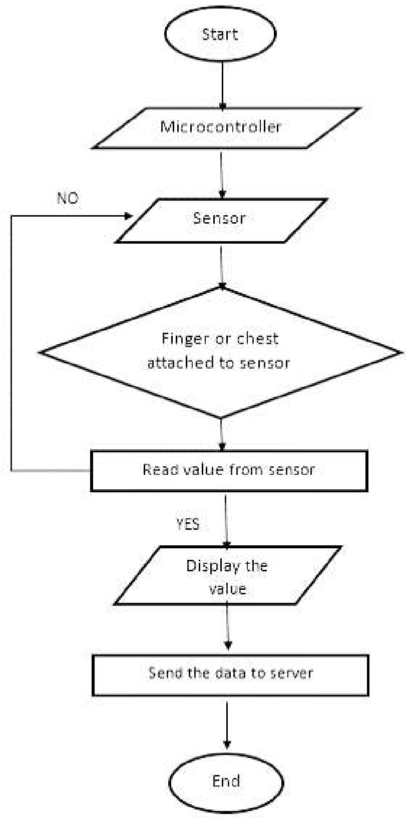

Figure 6: Flowchart of Project

Figure 6 shows the flowchart of the standard operation of the project. The Arduino will initialize the input and output positions once the system is turned on. The sensor will get its reading from the tip of a finger or from the chest. As a result, the value can be obtained when the patient places their finger or chest to a sensor, whether it is a heart rate SpO2 sensor or an ECG sensor. When the sensor detects a reading, it starts measuring the oxygen saturation and heart rate values, as well as an ECG reading. Then, the oxygen saturation and heart rate readings are displayed on the OLED, and the ECG readings are then sent to the IoT server.

2.5 Data Analysis Method

The system is made up of two parts which is hardware and software. Both components are necessary for the system, and users can obtain results from both. The analysis of the results is important in determining the effectiveness of the device during monitoring the patient’s condition. Therefore, the results of testing the device's performance are collected after the final hardware prototype is completed. The device was tested to ensure that it functions properly and that the data from COVID-19 patients is accurate. Figure 7 shows the corresponding sensor attached and ready to test. The sensor performance was measured by taking readings on a few subjects. After examining the system separately, it was observed that all sensors worked satisfactorily.

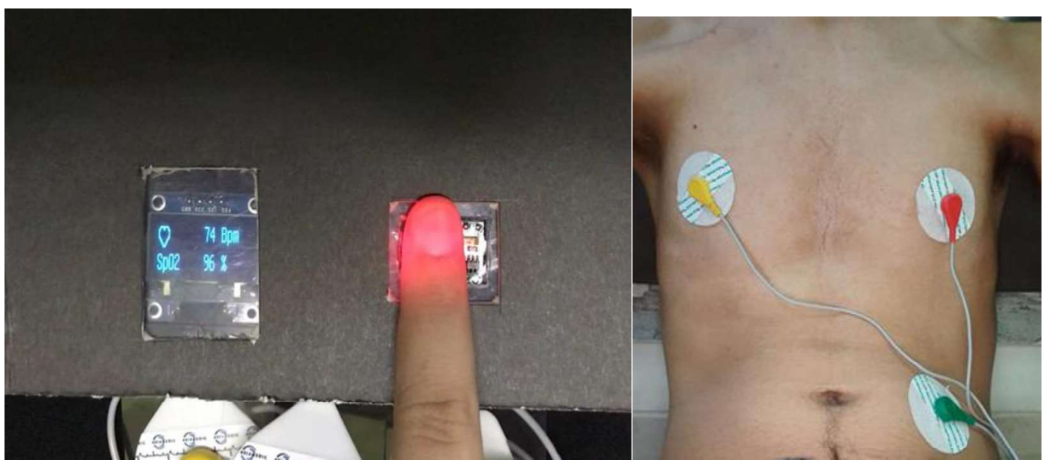

Figure 7: Testing the Heart Rate SpO2 sensor and ECG sensor

3. Result and Discussion

Referring on Figure 7, it shows the user experience of measuring the values of heart rate and SpO2 levels in which the user can see the displayed value on the OLED, and also shows the user experience of recording the ECG signal. The system passes the data to a mobile application, which then shows the result of the measured ECG signal of the user. With this device, users can get the results they need by looking at a screen or by using mobile apps.

The device was evaluated on a few subjects of different ages in different conditions. In the test cases, for heart rate and oxygen saturation levels, we recorded the actual value and observed value from the device. We then calculated the error rate from the data to demonstrate the device's effectiveness. As there is no alternative way to analyze the ECG signals, we simply display the subject's data from the Blynk application. Table 1 and 2 shows the actual and observed value with error rates for oxygen saturation levels and heart rate respectively.

Table 24: SpO2 data collected by machine (actual) and device (observed)

Subject	Age	Actual value (%)	Observed value (%)	Error rate (%)
Person 1	23	96	97	1.04
Person 2	24	90	93	3.33
Person 3	20	92	96	4.34
Person 4	25	93	99	6.45
Person 5	21	88	92	4.54

Table 25: Heart rate data collected by machine (actual) and device (observed)

Subject	Age	Actual value (Bpm)	Observed value (Bpm)	Error rate (%)
Person 1	23	70	73	4.28
Person 2	24	65	68	4.61
Person 3	20	73	72	1.36
Person 4	25	69	74	7.24
Person 5	21	64	69	7.81

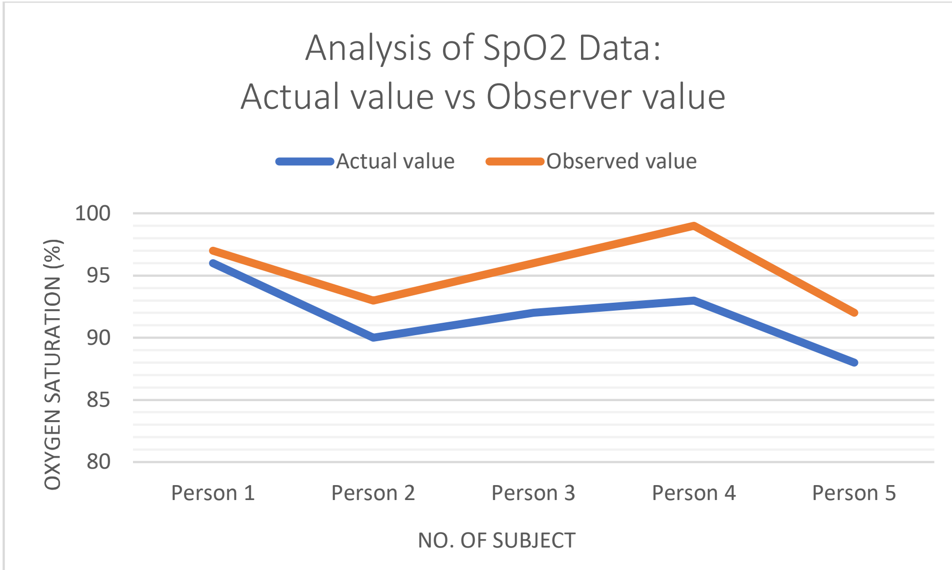

Figure 8: The result of SpO2 sensor

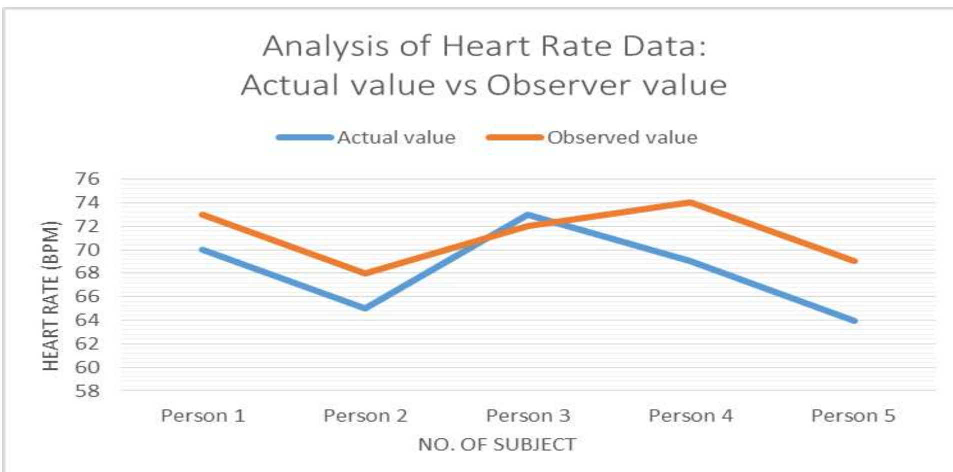

Figure 9: The result of Heart Rate sensor

The results of heart rate SpO2 sensor testing are shown in Figure 8 and Figure 9. It displays the difference between the actual value and observed value of the heart rate and oxygen saturation levels. According to the graph in Figure 8, most people's SpO2 levels were close to their actual values. For the graph in Figure 9, the heart rate values for the different subjects were comparable between actual and observed values. It was also discovered that the measured physiological data for the test subjects were different. As a result, the heart rate SpO2 sensor is relevant for use in this project. Hence, we can conclude that the system worked perfectly. On the other hand, Figure 10 illustrate the corresponding ECG data from five different subject shown in Blynk application.

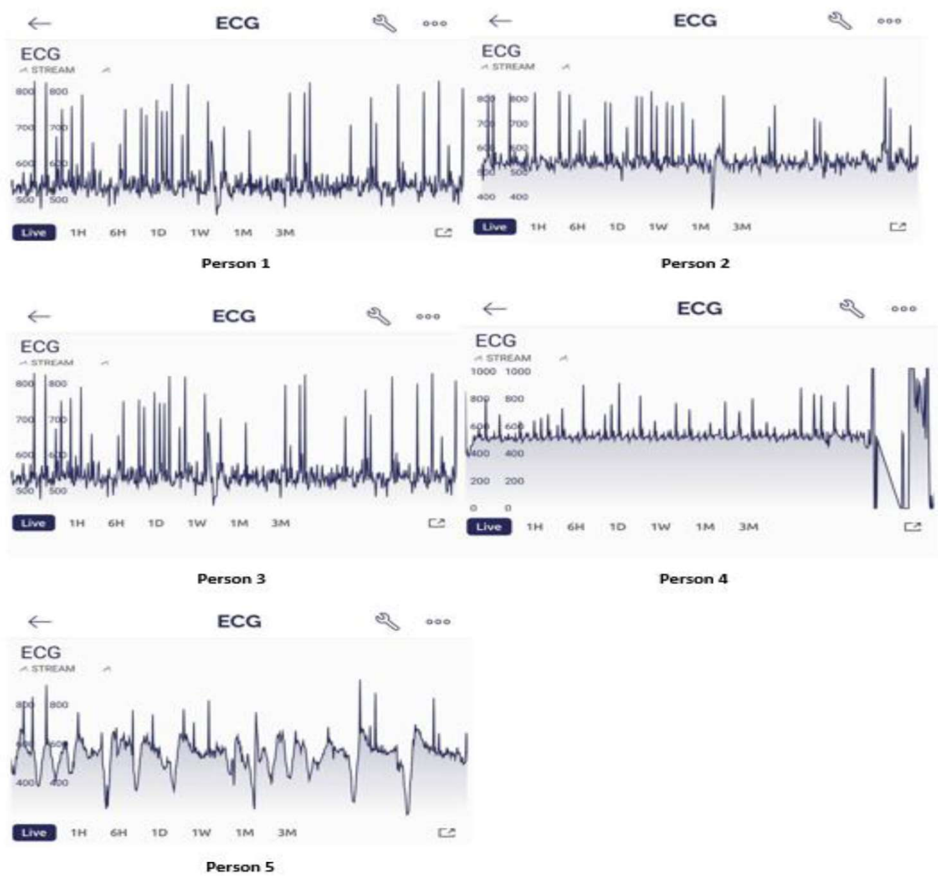

Figure 10: The result of ECG sensor

4. Conclusions

In a nutshell, the project was developed to make life easier for people who have health conditions and need to visit the hospital. From the beginning, we wanted to design a well-organized, application-based device that could be used in the current pandemic. Even though the tests are performed outside of the hospital, healthcare workers can view and track the data in real time. The system can also help nurses and doctors in pandemic situations because raw medical data can be analysed quickly. The system is also cost-effective and versatile, making it possible to diagnose patients' conditions no matter where they are.

5. Aknowledgement

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