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IoT Patient Monitoring System for COVID-19

Ummi Najwa Izzati Kamaludin[1], **Nur Ilyani Ramli**[1]*

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

*Corresponding Author Designation

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Abstract: The paper is focusing on implementing the Internet of Things (IoT) in a device that monitors the vital signs of COVID-19 patients namely the pulse rate, oxygen saturation and body temperature. The purpose of this work is to help in reducing direct contact of the medical healthcare providers with the patients and notify them if the patients need immediate attention. This device was built via a programmable microcontroller of NodeMCU ESP8266 where the readings of the vital signs collected by the sensors will be uploaded to the cloud so the readings can be displayed on the Blynk application and the hardware developed simultaneously. The sensors that are involved in collecting the body temperature are MLX90614 and pulse oximeter sensor MAX30100 for pulse rate and oxygen saturation. The medical staff will receive an alert notification in three situations which is when the pulse rate is more than 100 BPM, oxygen saturation in the blood (SpO_2) is less than 94% and the body temperature is 39°C and above. The data shows that the vital signs are accurate when being compared to the product that existed in the market. Hence, it can be used to reduce the risk on the healthcare providers being infected and in the development of the healthcare services. A further possible attempt may include the use of a microcontroller with a wider range for the medical staff's accessibility.

Keywords: COVID-19, Monitoring System, Pulse Rate, Oxygen Saturation

1. Introduction

The first COVID-19 case detected in Malaysia was on January 25th 2020 when 3 travelers from China were positive after being in close contact with someone who is infected in Singapore [1]. The number of COVID-19 in Malaysia was reported to grow after a religious event participated by 16,000 people on March 2020 was attended by a 53-year-old man who was confirmed positive for a virus when he returned to Brunei [2]. The patients infected by COVID-19 were detected with pneumonia and they will experience a wide range of symptoms from mild to severe, where the most common symptoms are cough, fever and shortness of breath [3]. COVID-19 are affecting the vital organs similar to SARS and MERS as the virus came from the same family[4]. Hence, during the treatment process of the COVID-19 patients, it is very important to monitor their pulse rate, oxygen saturation and body temperature. In

*Corresponding author: ilyani@uthm.edu.my

order to do so, the medical staffs will need to attend the infected patient regularly, causing the risk of the medical staffs to get infected increased.

Therefore, this IoT Patient Monitoring System for COVID-19 was developed to reduce the contact of the medical staffs with the COVID-19 patients. This objective of this device is to design a system that able to detect and process the vital signs of the patient, where the medical staffs receive notification about the changes of the patient's vital signs wirelessly as an indication that the patient need an immediate medical attention. It is expected that the medical staff will be able to monitor the pulse rate, oxygen saturation and body temperature of the COVID-19 patients from the device wear by the patient without making any direct contact or just by monitoring through their smartphones. The medical staffs also will receive the notifications if the system detect any changes on the vital signs based on the conditions of pulse rate more than 100 Beats Per Minute (BPM), the oxygen saturation in blood (SpO2) is less than 94% and if the body temperature is 39°C and above. If the system detects any of the conditions, the system will notify the medical staffs so that they will be able to attend the patient immediately and give them appropriate treatment.

The normal oxygen saturation for a healthy children and adults are in the range of 95-100%, while the level of oxygen saturation in range of 90-94% is known as hypoxia [5][6]. The oxygen saturation level of a patient that is positive with mild COVID-19 infection are 94% and higher, hence the patient need to be evaluate and monitor by medical staffs as if the level drop to 90% so that immediate treatment can be given to the patient [7]. Fever is another common symptom of COVID-19 infection, where the normal body temperature is 36.5°C, and the body temperature of a person with a fever can go up to 38.3°C and higher. Due to that, the parameter for the body temperature was set at 39°C as the maximum body temperature so that the medical staff can stay alert on the patient's fever [8]. When a person is having a fever, their pulse rate will tend to increase as the body is trying to recover. Since the normal pulse rate of a person at rest are between 60 to 100 bpm, if it is more than 100 the person will need a medical attention as too high pulse rate could be dangerous [9].

2. Materials and Methods

The NodeMCU ESP8266 microcontroller, a pulse oximeter sensor MAX30100, a temperature sensor MLX90614, OLED displays, and the Blynk application were all used in the building of this wearable system, as illustrated in Figure 1. The input data from the sensors of the pulse oximeter MAX30100 and the temperature sensor MLX90614 will be processed by the NodeMCU ESP8266 and uploaded to the cloud. The processed data will be transferred to an OLED display and the Blynk application for monitoring purposes both manually and wirelessly. The Blynk application will send a notification to the medical staff's smartphone when the system detects changes in vital indicators, such as heart rate, oxygen saturation, and body temperature, so that the patient may receive adequate treatment immediately.

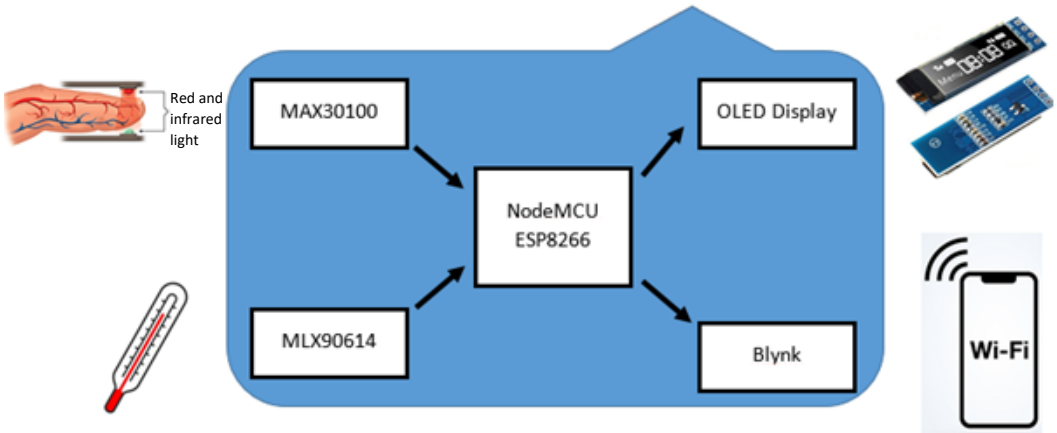


Figure 1: Block diagram of the system

2.2 Flow Chart

Figure 2 shows the flow chart of the system. The system will start to monitor the oxygen saturation first, followed by the pulse rate and the body temperature. There are three conditions need to be focused on which is the SpO2 lower than 94%, pulse rate that is higher than 100 BPM and body temperature that is 39°C and higher. If the system detected any of these condition, notification will be sent to the medical staff's smartphones to inform them about the changes and the patient will be able to receive appropriate medical treatment.

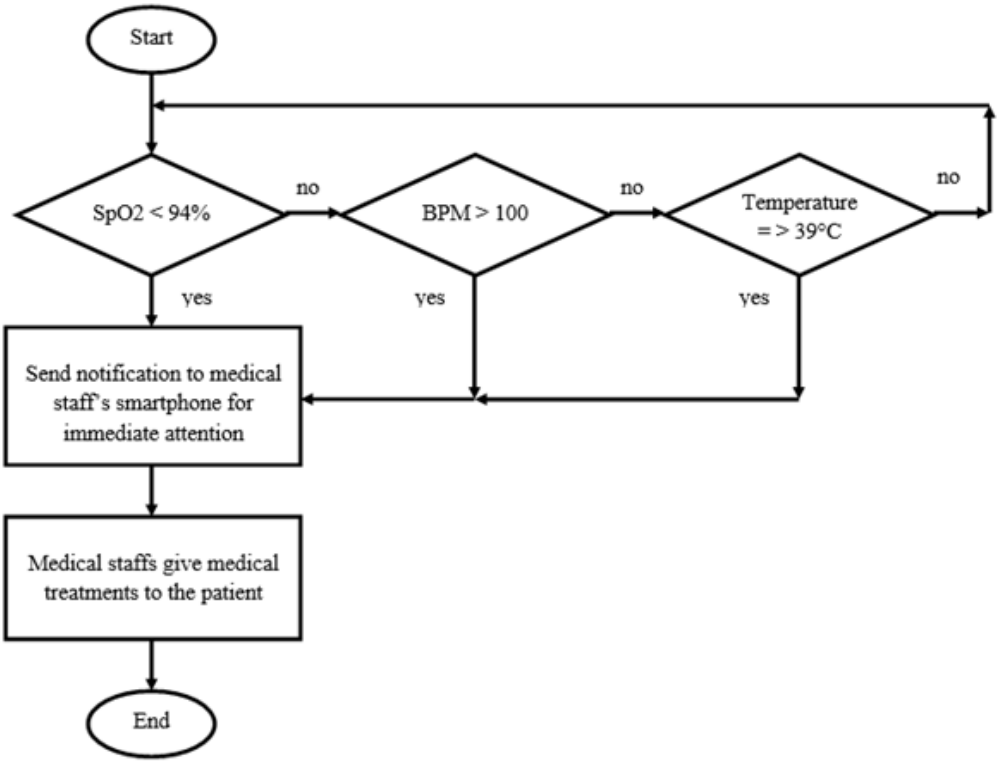


Figure 2: Flow chart of the system

3. Results and Discussion

The results in Table 1 was obtained from 4 subjects with different age, gender and medical history. In order to obtain the average readings of the oxygen saturation, pulse rate and body temperature, the vital readings of the subjects were monitored and compared with the pulse oximeter model X1805 TFT, while readings of the body temperature of the subjects was being compared with an infrared thermometer model CK-T1503.

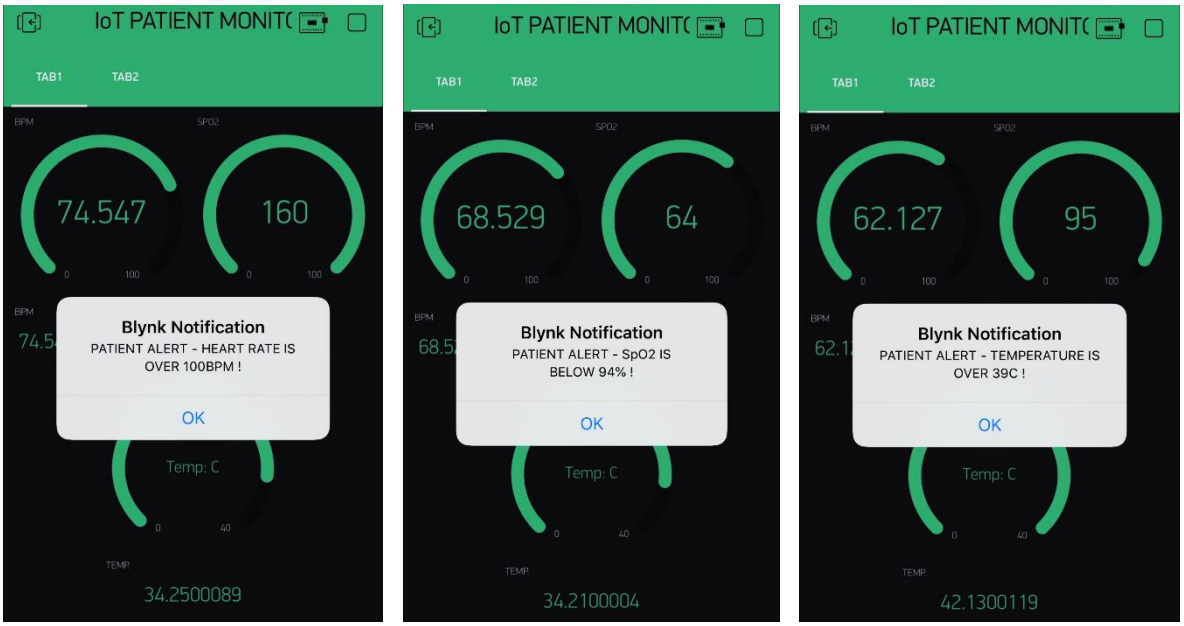
The data obtained were accurate and similar with the devices. Hence, this wearable system can be used as a wireless monitoring system by the medical healthcare providers when treating a COVID-19 patient as it will be very helpful in reducing the risk of the medical healthcare providers from getting infected by COVID-19.

Table 1: The average readings of vital signs from 4 subjects

	Oxygen Saturation, %	Pulse Rate, BPM	Body Temperature, °C		% of Error
			Device	Infrared Sensor	
Subject 1	98	80.21	36.6800012	36.68	0
Subject 2	94	72.76	37.0100040	37.01	0
Subject 3	99	67.98	36.9110003	36.91	0
Subject 4	98	65.35	36.6700011	36.67	0

Figure 3 shows the wireless monitoring system where the medical staff was able to monitor the real-time parameter from their smartphone through Blynk application, while Figure 4 shows the notification received by the medical staff if the system detected any changes on the oxygen saturation, pulse rate and body temperature. Figure 4(a) shows the notification pop up received through Blynk application when the heart rate more than 100 BPM. Figure 4(b) shows the notification pop up received through Blynk application when the oxygen saturation lower than 94% and the body temperature that equal to 39°C and above in Figure 4(c).

Figure 3: Real-time monitoring method through Blynk application from smartphone



(a) (b) (c)

Figure 4: The notification received through Blynk application when the system detected (a) changes in heart rate, (b) changes in oxygen saturation, and (c) changes in body temperature

4. Conclusion

Overall, in this project, the IoT patient monitoring system for COVID-19 has been developed successfully as this system allow the medical healthcare providers to monitor the vital signs of the patients wirelessly and without making regular contact. The medical healthcare providers also able to

receive notifications when the system detects any changes of the vital signs (i.e. pulse rate above 100bpm, oxygen saturation is lower than 94% and the body temperature that is equal and greater than 39°C). Based on the results obtained, it shows steady average on the pulse rate per minute, the percentage of the oxygen saturation and the body temperature. The results are also accurate as it is similar to the devices that are in the market. However, there are a few limitations of this system especially on the sensors. Therefore, it would be better if there are sensors that has the ability to process all three vital signs together especially by considering the pandemic. This system also can be improved by using other microcontroller that has the ability to cover wider range with the system design and material.

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