IOT COVID-19 Portable Health Monitoring System using Raspberry Pi, Node-Red and ThingSpeak

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***Abstract*— This project presents a reasonable budget system, designed to help doctors and guardians to monitor the wellness and health condition of their patients even from a distance. This is very important during COVID-19, where there is a need to keep a distance from people. The current monitoring systems at the hospital are mainly wired to bulk equipment for monitoring. There are also monitoring devices that can be used at home. They also have the restriction of movement towards the patient as the devices can only be applied at the bedside of the patient as they are connected by wires to the monitor. As the patient is restricted with their mobility, this interferes with their daily routine and the doctors and nurses at the hospital will have a hard time in keeping updates with the patient's condition. This paper presents an Internet of Things (IoT) based portable patient monitoring system that can be fixed to the remote patient without requiring the patient to be constrained by wires and remain at bed for the whole day. Furthermore, the device can measure and display the health status of a patient which is vital and needed for a better healthcare. Raspberry Pi is used as the central controller for the monitoring system. Sensors sent data through Wi-Fi that is integrated in the Raspberry Pi platform to the database. Similarly, for each of the sensors connected which are LM35 temperature sensor, AD8232 ECG Sensor, MAX30100 pulse oximeter sensor used MQTT server protocol to transmit the data to Node-Red and ThingSpeak for monitoring. The ThingSpeak displays real-time sensors' data and can be monitored on a webpage. An alarm is also sent through ThingTweet if needed. The obtained data from the sensors are saved on a database web page for offline smart pattern analysis in the future for the patient.**

Keywords—COVID-19, IOT, health monitoring, remote, Raspberry Pi, ThingSpeak

I. INTRODUCTION

The current surprising increase in the Coronavirus disease 2019 (COVID-19) cases causes many to be recommended to rest at home for self-quarantine based on the COVID-19 stage evaluation and limited places at our local isolation center [1]. Stage 3, 4 and 5 patients are occupying most of our local hospitals. Beds with proper monitoring system are inadequate [2]. This leads to more workloads towards doctors and nurses as they also need to attend each and every patient in their hospital to check the status of their health condition from time to time. Many are developing systems to help our front liners and optimize the systems for monitoring patients [3-5].

A. Patient Monitoring System

Patient health monitoring can be seen as a clinical supervision as the main aim of this system is to observe the status of health of the patients [6]. It can also display the information on the screen so that it is easier for the doctors to identify if there is any irregularity in the patient's condition. However, during this unexpected pandemic of COVID-19, it requires a significant change in monitoring system, especially for remote monitoring ability system. The COVID-19 virus can spread through a person's droplet of saliva or when the infected sneeze or cough. To prevent the transmission, it's the best to keep distances with anyone that might already be infected. This pandemic has caused majority of hospitals in the countries that are badly affected to be overwhelmed with the number of patients and some even reached the limit of their capacity. This causes those with stage 2 and 3 to be home isolated. On top of that patients that normally do their regular check-ups can be delayed too. These patients need a health monitoring device that can send data to the healthcare workers.

B. Internet of Things (IoT)

Internet of Things is a network of physical items that can be integrated with others such as sensors and other technologies as well as software. This is necessary to connect, transfer and exchange data with other systems over the Internet without having any intervention from humans. The 'thing' term refers to the device that can be connected to any sensors in order to alert for any issues happening with the ability in gathering and transfering data [7].

The IoT is influencing our lifestyle, from the way we react to the way we behave. The IoT is a giant network capable of connecting devices. It is physical devices with network that are embedded with sensors and network connectivity to gather and exchange data [7]. In the simplest of terms, it transforms everyday items into smart devices, capable of transmitting data and automating tasks without manual intervention from a user.

There are layers of IOT Internet of things that can be viewed into five different layers [8]. They have their unique responsibilities and functionalities.

1. Perception Layer: Sensing devices are placed on this layer, responsible for data gathering and passing them to upper layers.

2. Network Layer: This is a communication layer and placing security to the data. Its main function is transfer of data between lower and upper layers.

3. Middleware Layer: Data storage occur at this layer. It can also handle service management.

4. Application Layer: This layer is mainly providing all types of services with respect to the corresponding field.

5. Business Layer: Analysis can be done on this layer. This is where, further actions of data can be planned and guided.

C. Cloud Computing

Data storage and data manipulation are crucial in the real-time implementation of IoT applications. Therefore, Cloud computing is a platform that can equip the much-needed solution for large data storage and high transfer rates [9].

II. Proposed System

Throughout this project, the system is being invented in order to help the doctors and guardians to monitor the patient's health and condition remotely. The system is designed as a monitoring system in healthcare as it also prioritizes wireless connections involving sensors that will measure parameters in order to observe the condition of a patient.

This project's development will focus on the data recording and monitoring system of the sensor networks of the system, which will be displayed on a cloud computing application. Raspberry Pi will be used as the central platform for the monitoring system. The measurement and reading from sensors will be sent to the Cloud system through Wi-Fi that is integrated with the Raspberry Pi platform.

A. Monitoring System Block Diagram and process flow

Figure 1 shows the block diagram of the portable health monitoring system that consists of all of the sensors used to monitor the patient's health.

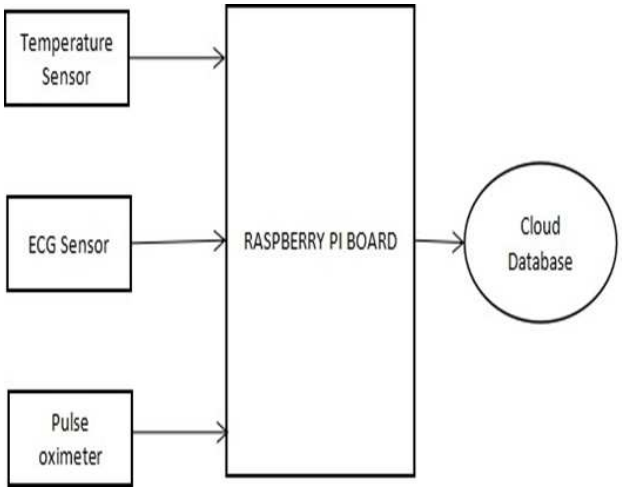

Fig. 1. The block diagram of the system

Figure 2 shows the flowchart of the portable health monitoring system that explains the flow of the project. The Raspberry Pi is the central control board of this system. Firstly, the system requires connection to be established to the Node-RED server and MQTT broker via Wi-Fi network. After that, all the sensors are initialized, and then the sensors will start to detect the parameter which is the health condition of the patient. The Raspberry Pi will read the data recorded from the sensors as well as publishing the data through MQTT broker to the subscribed topics. The data is then collected from the Node-RED software and saved to the Thingspeak. Moreover, the user can monitor the database through their smartphone and desktop.

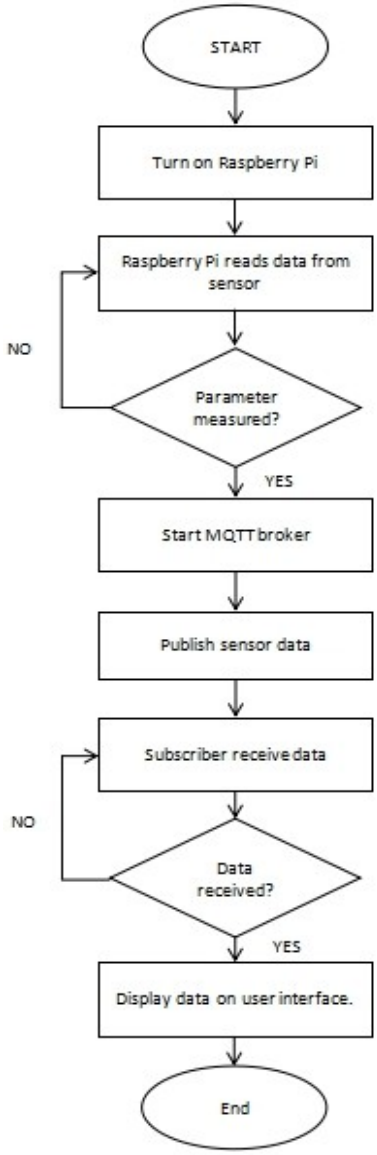

Fig. 2. Flowchart of the monitoring system

B. Software Components

IOT project requires software platform for managing devices and receiving and processing data. This platform provides APIs for reading and gathering data. This platform supports different communication protocols such as MQTT. Platform is deployed in the cloud, but it can also be run on other premises if the data is too big.

- Node-Red

Node-RED is a flow-based development tool for visual programming for wiring together hardware devices, APIs, and online services. This program is used as the connection tool of the hardware and Cloud computing and thus becoming the core of this Internet of Things project. This program also provides a web browser-based flow editor, which can be used to create JavaScript functions. The

runtime is built on Node.js. The flows created in Node-RED are stored using JSON.

- MQTT Protocol

MQTT is a standard messaging protocol for the Internet of Things (IoT). It uses small bandwidth, light-weight, and is appropriate for remote devices. This messaging protocol is used in this system for publishing and subscribing to the data from the sensors.

- ThingSpeak Monitoring Platform

ThingSpeak is an IoT analytic platform service that allows the user to aggregate, visualize, and analyze live data streams in the cloud. ThingSpeak is an IoT cloud platform where the user can send sensor data to the cloud and monitor gathered data.

Figure 3 shows the connection of sensors with the database involved and the use of Node RED and ThingSpeak on the Raspberry Pi platform through internet connection. It contains the necessary functions for the setup of communication protocol and storing information.

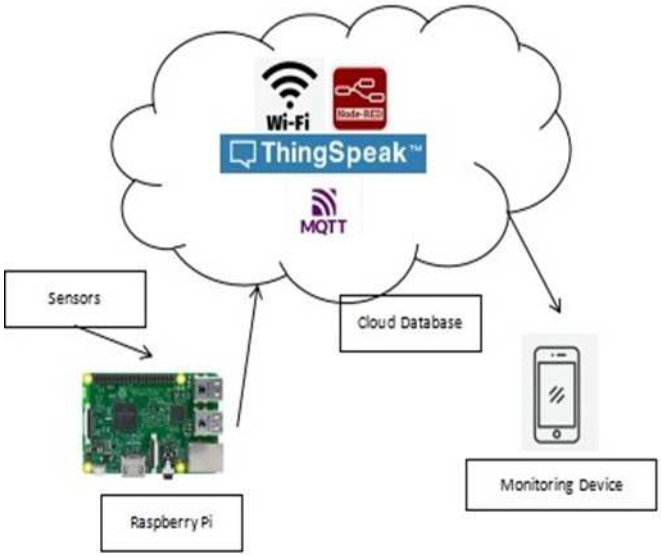

Fig. 3. Monitoring System architecture

C. *Hardware Components*

Devices and sensors are the "Thing" part in any of the IOT system. Hardware interacts with the physical part. The main important elements for this "thing" part are the accuracy to read the behavior of the application and proper integration with the overall system architecture as shown in figure 3. Another important element is device configuration. There are two types of configurations, internal configuration or external reconfiguration using programming. Power source must also be evaluated for feasibility.

This project uses the following hardware.

- Raspberry Pi 3 Model B

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This Raspberry Pi is able to be used for many applications. It is a compatible platform to be used in IoT project as it has wireless LAN and also bluetooth connectivity. It will be used as the central controller for monitoring system with power supply of 5V. Figure 4 shows the picture of this device.

Fig. 4. Raspberry Pi 3 Model B

- LM35 Temperature Sensor

Figure 5 shows the LM35 Temperature sensor. It is an analog linear and a precision IC temperature sensor. The output of this sensor is proportional to temperature. The measuring of temperature is more accurate when using LM35 instead of standard thermistors. It will be used to detect the temperature body of the patient.

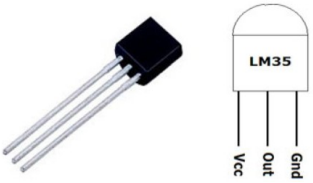

Fig. 5. LM35 Temperature Sensor

- AD8232 ECG Sensor

The AD8232 is an integrated signal conditioning block for ECG applications. AD8232 is designed to take readings for heart rate. This is shown in figure 6.

Fig. 6. AD8232 ECG Sensor

- MAX30100 Pulse Oximeter

MAX30100 is an integrated pulse oximetry and heart-rate sensor. It reads the oxygen levels within the blood. This oximeter is in figure 7

Fig. 7. MAX30100 Pulse Oximeter

III. Implementation And Display

The development of portable health monitoring system involving sensors is done and placed on vest for portability. The patient can wear the portable health monitoring system

while the sensors detect the patient's parameters without having too many difficulties moving or being restricted by wires.

Figure 8 shows the front view of the prototype portable health monitoring system containing all the sensors being attached to a vest. The ECG patch will be placed on patient's body. The location on patient body is shown in figure 8.

Fig, 8. Hardware setup of the portable health monitoring system

Figure 9 shows the hardware setup from inside the vest containing the raspberry pi and power supply.

Fig. 9. Hardware setup within the vest

Figure 10 displays the portable health monitoring system vest being worn by a user. As shown above, the user is not restricted by cables that would force the patient to remain in bed with movements being restricted. ECG patch should be on the patient's body.

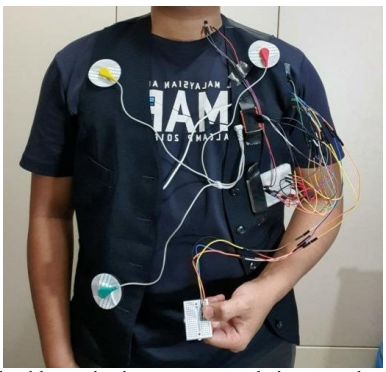

Fig. 10. Portable health monitoring system vest being worn by a user.

A. Monitoring System Display

Figure 11 shows the data recorded that has been displayed from application ThingView installed in the smartphone. The doctor and guardian of the patient can keep up to date with the condition of the patient through smartphone. The following labels are the parameters measured by the sensor. The pulse is being measured by ECG for the heart rate reading, the SpO2 is being measured by MAX30100 pulse oximeter for the oxygen levels within the blood and the temperature is being measured by LM35 temperature sensor for body temperature.

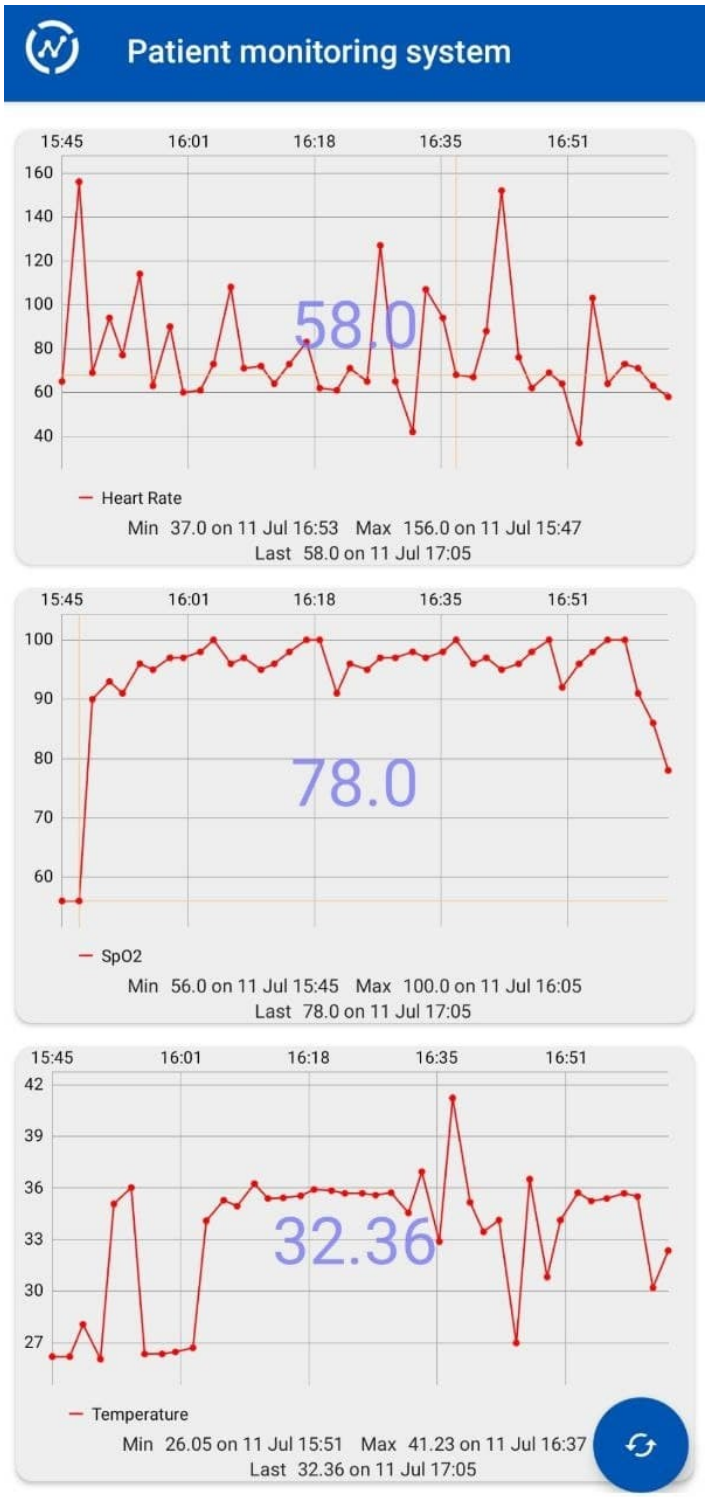

Fig. 11. Health monitoring of the sensors through smartphone.

Figure 12 displays the data recorded on the webpage. Aside from mobile phone, the doctor and guardians can also monitor the patient's health condition through the webpage.

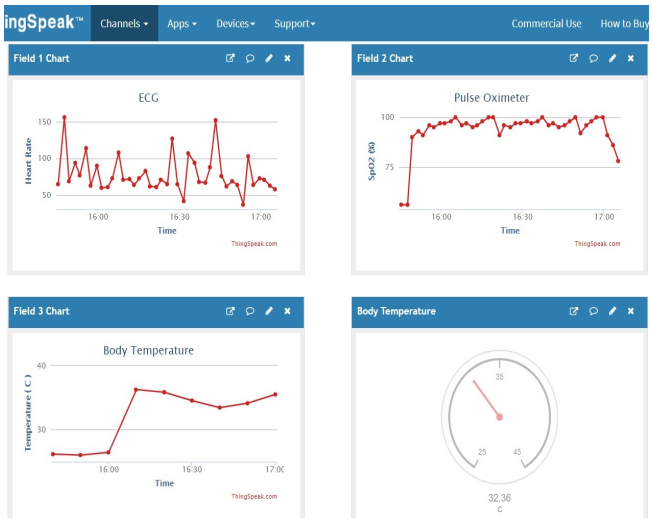

Fig. 12. Health monitoring of the sensors through desktop view

Figure 13 shows how that the system will notify the guardian or doctor whenever the patient's parameter are abnormal depending on the value being set up. This system works with the ThingsTweet from the ThingSpeak as the twitter account being linked up with the ThingSpeak act as an alert notification. It can be set up as private only to the doctors and guardians.

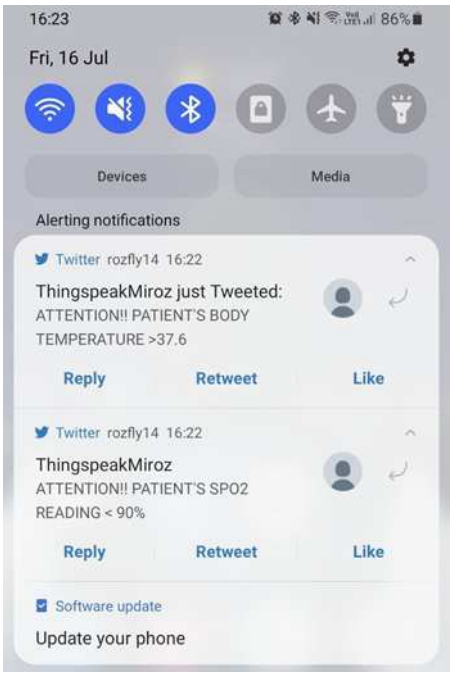

Fig. 13. Alert System

Figure 14 shows the recorded data of patient monitoring system being extracted from the ThingSpeak. The extracted data can be used as reference for the patient's health condition and could be further analyzed for offline data manipulation.

	A	B	C	D	E
1	created_at	entry_id	field1	field2	field3
2	2021-07-11	1	65	56	26.19
3	2021-07-11	2	156	56	26.34
4	2021-07-11	3	69	90	28.07
5	2021-07-11	4	94	93	26.05
6	2021-07-11	5	77	91	35.07
7	2021-07-11	6	114	96	36.03
8	2021-07-11	7	63	95	26.35
9	2021-07-11	8	90	97	26.04
10	2021-07-11	9	60	97	26.47
11	2021-07-11	10	61	98	26.71
12	2021-07-11	11	73	100	34.09
13	2021-07-11	12	108	96	35.29
14	2021-07-11	13	71	97	34.95
15	2021-07-11	14	72	95	36.25
16	2021-07-11	15	64	96	35.39
17	2021-07-11	16	73	98	35.43
18	2021-07-11	17	83	100	35.55
19	2021-07-11	18	62	100	35.91
20	2021-07-11	19	61	91	35.85
21	2021-07-11	20	71	96	35.69
22	2021-07-11	21	65	95	35.60
23	2021-07-11	22	127	97	35.59
24	2021-07-11	23	65	97	35.73
25	2021-07-11	24	42	98	34.55
26	2021-07-11	25	107	97	36.95
27	2021-07-11	26	94	98	32.89
28	2021-07-11	27	68	100	41.23
29	2021-07-11	28	67	96	35.17
30	2021-07-11	29	88	97	33.45

Fig. 14. Extracted data for database

IV. Conclusion

In conclusion, the portable health monitoring system has been completely developed for the purpose of monitoring the patient's well-being through the reading of their parameters, including body temperature, oxygen saturation level in the blood, and the heart rate of the patient from devices such as smartphones. This project was developed to be automatic without having raw energy or human work to manually take the readings of parameters, as they can just monitor the readings from the smartphone. There are less wires connecting the system without having it restricting the mobility of the patient and thus, the patient can continue their daily routine while using the portable health monitoring system. As long as there is internet connection in the area, the web channel of the parameters reading can be accessed so it is possible to monitor the patient remotely and from distances.

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