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A Cost Efficient Contactless IoT based Body Temperature Detection System

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Abstract - **In the recent outbreak of Covid-19 pandemic, various methods has been adopted to prevent and control the wide spread of pandemic. One of the commonly used method is by detecting the body temperature. This is to isolate those obtained higher body temperature who are possibly infected with the virus. Body temperature detection device is commonly deployed at the entrance of merchants for this purpose. However if one person is detected in one merchant with higher body temperature, this information is not bundled with his/her identity information. Therefore his/her entranced to other merchants are not linked and warned, and causing a possible spread of pandemic if other customers who appeared in the same premises are not being notified. In this work, an IoT based body temperature detection system is developed. In this system, the body temperature data is obtained and sent to the internet cloud together with the identity information of that person. This allow easy tracking of the potential virus infected person. The collected data can be further analysed using online analysis tool. Furthermore, the identity information is obtained using QR code which eliminate the ordinary procedure of writing personal data into logbook. The QR code method is contactless and able to avoid the infection of virus through the contact of pen and logbook. This system is developed with low-cost material and is affordable for small merchants.**

Keywords—IoT, Node MCU, Wi-Fi, Adafruit IO

I. Introduction

In the current event of Covid-19 pandemic that threatening the safety of human race, various systems have been developed using the advantage of IoT infrastructure to prevent the wide spread of the pandemic. Human body temperature detector is one of the most common devices being used. The temperature detector is used to detect the human body temperature in order to increase the chances to detect the potential virus carriers, and therefore prevent the virus from wide spreading. A scenario in the current implementation of temperature detector in Malaysia is to detect the body temperature when a person entering a shop, and the identity information of that person is hand-written in a logbook or scanning is done using the MySejahtera mobile apps. If these information is hand-written in the logbook, these data are not always being checked and person with potential virus carrier with higher body temperature will not be properly traced. If MySejahtera apps is used, the body temperature information obtained by the body temperature detector is not captured and linked to the identity information. It is not possible to track the potential virus carrier.

There are many other different methods or systems being used for the same purpose of detecting the potential virus carrier with higher body temperature. One of the current implementations is using thermal camera by Vodafone UK. The company has a partnership with Digital Barriers that has manufactured a heat detection camera to detect person infected with coronavirus pandemic. It was stated that the camera is able to check the temperature of 100 people per minute; as the thermal images are streamed or viewed in a device like phone or a laptop as such the analytics can be viewed instantly. The solution that was provided by this system was said to screen up to 8 people at a time and 100 people every minute. The thermal camera have very high potential in securing public from the current wide spread of pandemic and it is suitable to implement in a crowded area [1]. However not all public areas will be able to install it due to a very expensive implementation which a cost of UK £1,711 per month for 12-month payment plan.

Another current integration of thermal cameras is the IRSX camera made by a Germany company called Automation Technology GmbH. One of the main advantage of this device is to provide a contactless alternative compared to the use of Resistance Temperature Detector (RTD) and thermocouple sensors that was usually used in the past [2]. These cameras are known to offer a combination of industrial and web-communication based protocols, which are made for IoT applications. This camera based solution is called Movi-THERM-Advanced Thermography Solution and constructed by FLIR Systems Inc.. However, this device has yet to incorporate with real time analysation.

The problems with the current existing body temperature detection system and its implementations are as follows:

1) The price of body temperature detector system is too expensive and not affordable by small merchants.
2) The body temperature data and person's identity information are obtained and kept separately causing difficulty in tracing the potential virus carrier.
3) Body temperature data and identity information are not kept online for real time analysis.

In this work, the focus is primarily on obtaining and integration of the body temperature data and personal identity information. These information are obtained through contactless method and being pushed to the internet cloud using IoT technology for real time analysis and notification. The low-cost and simple implementation of the system is suitable for small organisations or merchants and able to provide them with a more manageable data.

Internet of things (IoT) is known to be able to connect devices and users through unique identifier (UID). It can be generalized for having the ability to transfer data or information over the network without human-to-human or human-to-computer interaction [3]. It is an inter communication embedded device via networking technologies which is expected to play an important role in the near future at many industries, business and even household. Basically, an IoT based system consists of web-enabled smart device such as embedded peripherals like sensors and wireless module. They are able to collect, send and execute the data received.

The key component that plays an important role to develop an IoT environment is the embedded system. Generally, the IoT environment has four key components. They are the Internet, the device with the capability of transferring real time data over the network, proper well-established network with gateway and the Back-End Services that is used to store the data [4]. With the recent developments in sensors technology has also contributed to the implementation of IoT based system. A Wireless Sensor Network (WSN) is developed from many types of sensor that monitors the environmental parameters continuously. The data obtained then will be collected and transferred via one network node to another.

For any constructed system, maintaining security is essential [5]. The IoT architecture that able to maintain the security of the IoT data can be represented with four types of interconnected system such as things, gateways, network, and cloud. The first element, "Things" is refers to the IoT environment require things which are capable of filtering data and manage the data as it is connected to the network. For example, mobile phones and smart buildings. The second element is the "Gateway" which most of the device used to acquire data through networking. Hence, gateways are used as an intermediate in between the Internet and the things. The third element which is the "Network" refers to the worldwide structure of interconnected IP addresses that connects billions of computers. Finally, the "Cloud" which contains a pool of virtual servers that are connected. The cloud can run different application that allows the capability of analysing the data collected from different sensors.

II. System Implementation

A. System Architecture

The IoT body temperature detection system proposed in this work is handy and low cost, and can be easily implemented in any premises to scrutinize the body temperature of anyone who enter the premises. Figure 1 shows the system flowchart of this system which illustrates the process flow on how the system being executed. When one person enters a premise, a motion sensor is used to detect the entrance of the person into the premise and the body temperature is taken by scanning the forehead of the person. Green LED light will turn on showing the completion of this process. At the same time, the obtained body temperature data is sent to the cloud and store in an online spreadsheet. Then the person need to scan the QR code which displayed

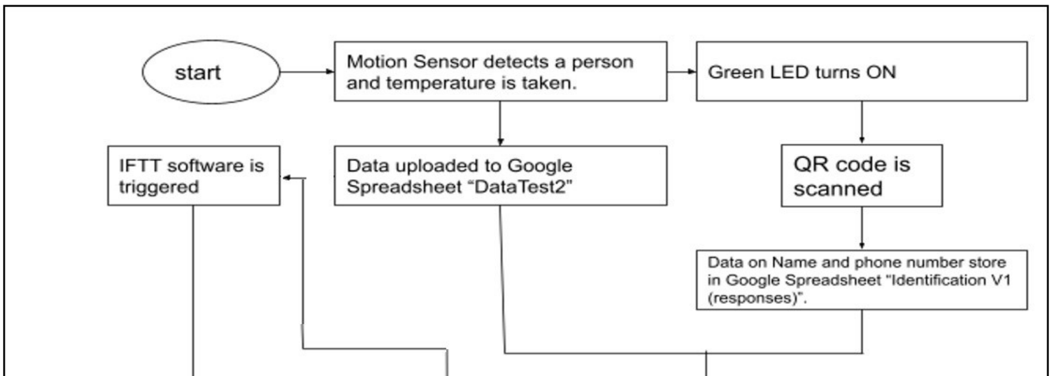


Fig. 1. System flowchart.

at the premise and fill in personal detail such as name and phone number to the online form. The identity information of that person is sent to the cloud and append to the same online spreadsheet. An online service software called "If This Then That" (IFTTT) is used to trigger another online platform called Adafruit. These data are uploaded to Adafruit from the online spreadsheet. The real time monitoring is done on Adafruit platform.

The hardware implementation of the proposed IoT based body temperature detection system is categorized into three functional modules, which are Sensing module, Wi-Fi module and Integration module. The Sensing Module is developed to turn on or enable the IoT based temperature detection system. The Wi-Fi module perform the integration between the sensed data and cloud server database [5]. It constructs the connectivity of other two modules. The measurement of the data accuracy is taken to evaluate its performance. Finally, the Interaction Module displays the real time output by graphs and charts. The flowchart of data transfer is shown in Fig. 2.

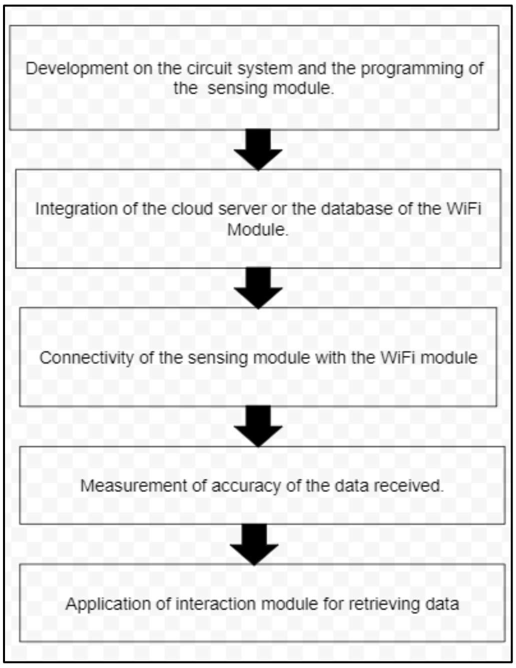


Fig. 2. Illustrate the flowchart of data transfer.

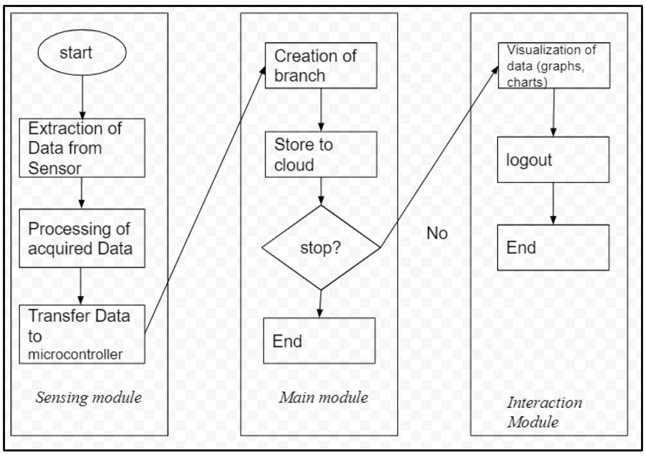


Fig. 3. Functional block diagram of the system to show basic data flow.

The system hardware is categorized into the functional of three main modules as shown in Fig. 3. Each module has its respective function to make sure the data transfer smoothly in the system.

Figure 3 shows the functional block diagram of data flow in the three modules. The first module is the sensing module. This module extracts the data from the sensor. The acquired data is processed and transferred to the microcontroller. The second module is the Wi-Fi module. This module serves as the decision making centre where the software programming plays the major role where the data is transferred to the cloud or server. Finally, in the Interaction module, the visualisation of data in the form of graphs and charts can be observed.

B. System Development

i. Sensor Module

Figure 4 shows the schematic diagram of motion sensor and Node Microcontroller Unit (NodeMCU). NodeMCU is an open source firmware and development kit with in-built wireless fidelity (Wi-Fi) feature. The NodeMCU used in this system is ESP8266 module. Figure 5 shows the schematic diagram of temperature sensor module, MLX90614 and NodeMCU. From Fig. 5, it shows the connection of the 3v3 pin of NodeMCU to the Vdd pin of MLX90614. The ground pin of the NodeMCU ground is connected to the ground pin of MLX90614. The Serial Clock (SCL) pin of the NodeMCU is connected to D1 pin of MLX90614, while the Serial Data (SDA) pin is connected to D2 pin. For the motion sensor, Echo pin is connected to D6 pin of the NodeMCU and the Trig pin is connected to D5 pin of the nodeMCU. Two LEDs light is being utilised with each LED connected to a 1KΩ resistor. Each LEDs is connected to pin D7 and D8 of the NodeMCU respectively. Table 1 shows the summary of the connections.

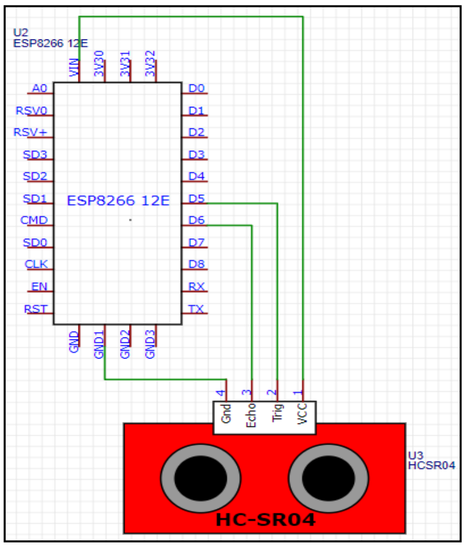


Fig. 4. Schematic diagram of motions sensor (HC-SR04) and NodeMCU (ESP8266).

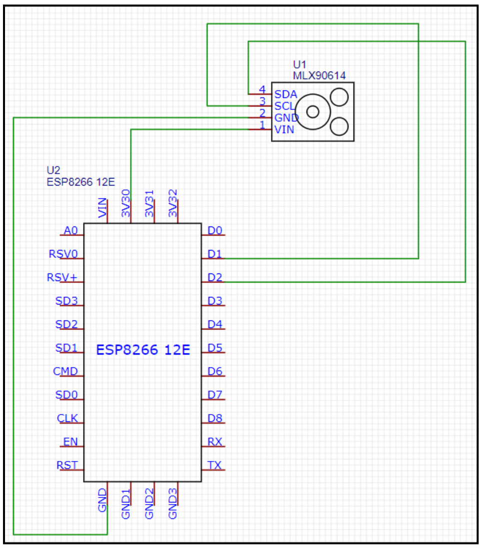


Fig. 5. Schematic diagram of temperature sensor (MLX90614) and NodeMCU (ESP8266).

Table I: The connection of NodeMCU and sensors.

Component	Pin	Component		Pin
Node MCU (ESP8266)	D1	Thermal Sensor (MLX90614)		SCL
	D2			SDA
	3V3			Vin
	GND1			GND
	D6	Ultrasonic Distance Sensor (HC-SR04)		Echo
	D5			Trig
	VCC			Vin
	GND			GND
	D7	Resistor (1 K ohm)	LED1	Anode
	GND			GND
	D8	Resistor (1 K ohm)	LED2	Anode
	GND			GND

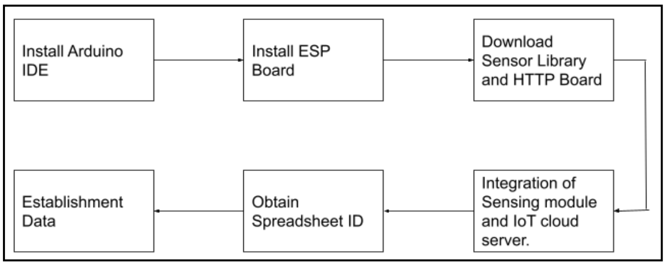


Fig. 6. Flowchart on the integration of Wi-Fi module.

ii. The Wi-Fi Module

The programming part of the NodeMCU is done by utilising the Arduino Integrated Development Environment (Arduino IDE) [6]. And the temperature sensor module, MLX90614 library is adopted to configure the temperature sensor. An open source Hyper Text Transfer Protocol (HTTP) server library is used for establishing a connection with the online Google Sheets. The connection between the NodeMCU and the google sheet is established specifically for the storage of temperature data into the spreadsheet. To do that, the spreadsheet must also be established as a web application. Figure 6 shows the flowchart on the integration of Wi-Fi module. It shows the process of data being captured and transfer into the cloud.

iii. Interaction Module

For this part of the system, two interaction modules are utilised which are the google spreadsheet and the Adafruit IO. Adafruit IO is an online platform designed to display and interact with data. The functionality of the Google Spreadsheet is to store the temperature data in real time in a secure manner. The complete set of temperature data and identity information are obtained and stored inside the spreadsheet. Meanwhile, the Adafruit IO is used to analyse and display the data following the system implementation given in Fig. 7. Once the IFTTT software detect a complete row of data, an alert are triggered. The trigger will enable the complete data to be sent to Adafruit IO platform and it can be viewed in real time as demonstrated in Fig.8.

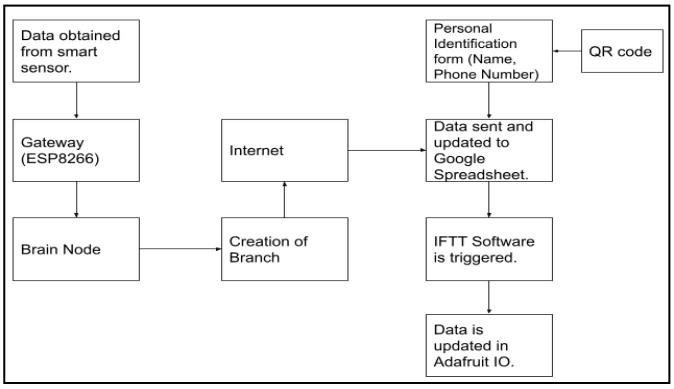


Fig. 7. Block diagram for the system implemented.

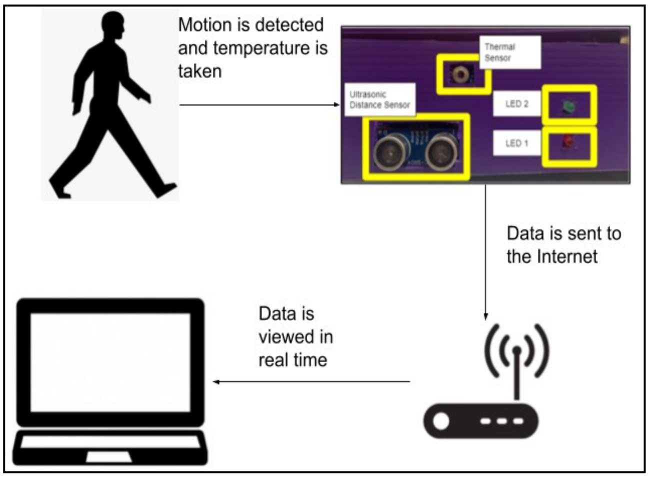


Fig. 8. Implementation of the IoT based body temperature detection system.

III. Results and Discussion

A. Body Temperature Result

A prototype of the proposed system is developed and tested. When a person approaching the prototype by approximately 20 cm, the motion detection sensor will detect the present of the person. The temperature sensor, MLX90614 is enabled and the body temperature of the person is obtained. The temperature sensor detects the body temperature by the infrared emission radiated by the person which could range in between 32 to 38 degree Celsius. Higher temperature results in higher kinetic energy allowing higher infrared radiation to be emitted [7].

The body temperature data obtained from the MLX90614 is sent to the online Google spreadsheet through NodeMCU gateway. The spreadsheet is named "TestData2" as shown in Fig. 9 which only documented body temperature data.

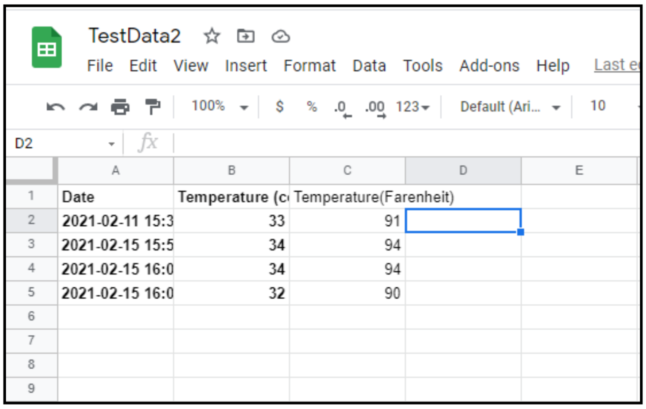


Fig. 9. Test data documentation in Google Spreadsheet.

As soon as temperature data is inserted in the spreadsheet, the integrated IFTT software will trigger and data from the Google spreadsheet "TestData2" will be transferred to Adafuit IO platform. These data are visible to the platform user where the temperature data can be monitored in Adafruit's online dashboard in real time. In this project, three widgets are used for monitoring purpose. The first widget allows users to monitor the temperature in real time once new data is obtained. This widget has a resemblance of a monitoring module. The second widget allows user to monitor the temperature obtained throughout the day. The last widget is displayed in graph, which shows the average temperature based on the setting of time period. The range of time setting in the graph is ranged from current real time to a period of 30 days.

Figure 10 shows the real time monitoring of temperature by one of the widget from Adafruit IO. Figure 11 and Fig. 12 show that the data can be displayed in text format and graph respectively.

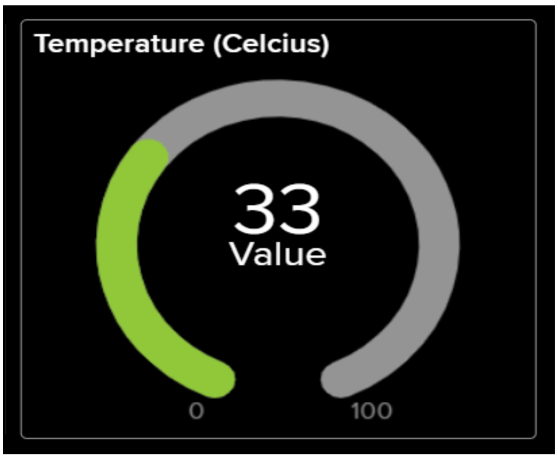


Fig. 10. Real time monitoring widget of Adafruit IO.

Fig. 11. Widget of Adafruit IO that documents the data throughout the day.

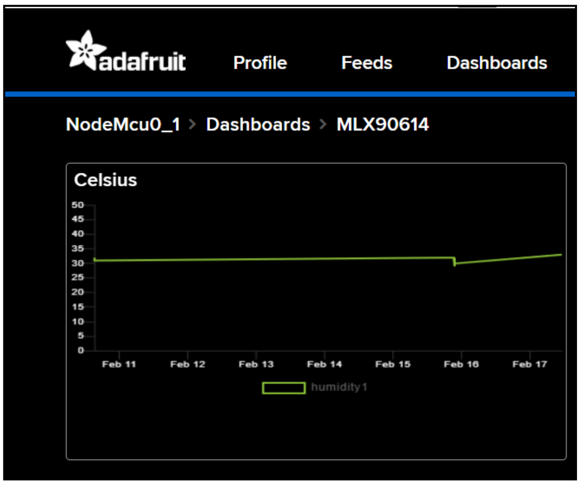


Fig. 12. Widget of Adafruit IO that documents the data in graph.

These data stored in Adafruit platform can be retrieved in table format and graph format and allowed for downloading. Figure 13 shows the graph and the list of body temperature.

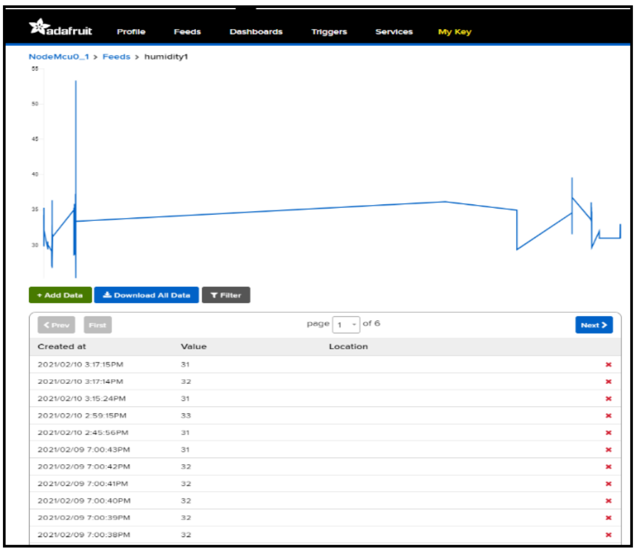


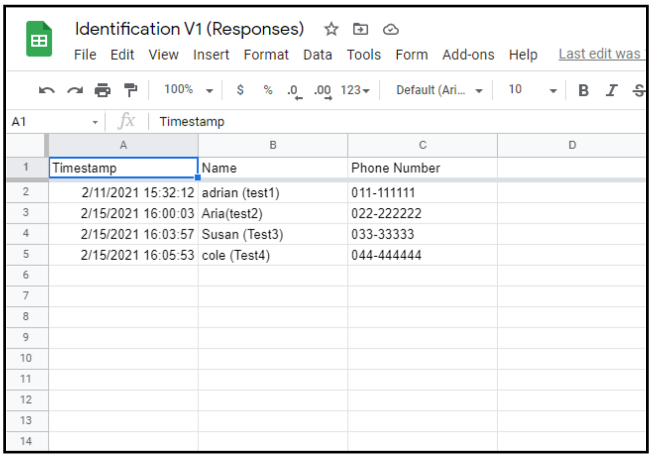
Fig. 13. Data displays in graph and table format.

B. Extraction of Personal Identity Information

After the body temperature being obtained by the temperature sensor, personal identity information of the person who enter the premise is acquired through a QR scanning. The scanning of the displayed QR code (Fig.14) at the premise using mobile phone apps will direct the browser to an online Google form asking for the name and phone number. Every premise or merchant has a unique QR code so that the tracking of data set can be done easily.

Fig. 14. QR code to access the Google Form.

The keyed-in name and phone number in the Google form are automatically recorded in an online Google spreadsheet named "Identification V1 (Responses)", as shown in Fig. 15. Every new set of information being keyed-in will be updated and appended in next row inside the spreadsheet.

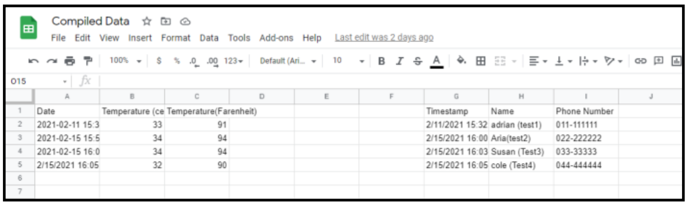


	A	B	C	D
1	Timestamp	Name	Phone Number	
2	2/11/2021 15:32:12	adrian (test1)	011-111111	
3	2/15/2021 16:00:03	Aria(test2)	022-222222	
4	2/15/2021 16:03:57	Susan (Test3)	033-33333	
5	2/15/2021 16:05:53	cole (Test4)	044-444444	

Fig. 15. Google Spreadsheet for every response from personal identification form.

C. Compilation of Body Temperature and Personal Identity Information

The body temperature data and the identify information are obtained separately and being kept in spreadsheet named "DataTest2" and "Identification V1(Responses)" respectively. Therefore both data needed to be linked and bundled together. In order to compile both set of data from separate spreadsheet into one, a third spreadsheet is created which named "Compiled Data". A function was used to link both spreadsheets into the new spreadsheet. The function links the URL address of the two aforementioned spreadsheets, and coded as "IMPORTRANGE ("spreadsheet URL"," Sheet1! A1:C")". Figure 16 shows the compiled spreadsheet with body temperature data and identity information.



	A	B	C	D	E	F	G	H	I
1	Date	Temperature (ce	Temperature(Farenheit)				Timestamp	Name	Phone Number
2	2021-02-11 15:3	33	91				2/11/2021 15:32	adrian (test1)	011-111111
3	2021-02-15 15:5	34	94				2/15/2021 16:00	Aria(test2)	022-222222
4	2021-02-15 16:0	34	94				2/15/2021 16:03	Susan (Test3)	033-33333
5	2/15/2021 16:05	32	90				2/15/2021 16:05	cole (Test4)	044-444444

Fig. 16. Google Spreadsheet of the compiled data.

D. The Prototype

Figure 17 shows the front view of the prototype of the IoT based body temperature detection system. The wiring connections are hidden inside the prototype box.

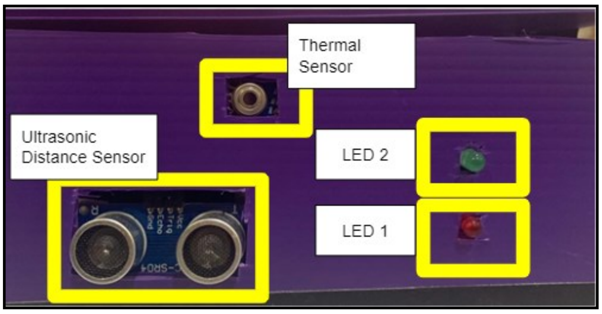


Fig. 17. Front view of the prototype.

The connection of the sensors and LED of the prototype shown in Fig. 17 is listed in Table I. The NodeMCU is connected to the temperature sensor (MLX90614) and the ultrasonic distance sensor (HC-SR04). The Vin pin of the NodeMCU provides the voltage supply for the sensors with the values of 5V. Meanwhile, the ground (GND) pin of the sensors is connected to the Ground pin of the NodeMCU and the cathode of the LEDs. The anode of the LED is connected to a 1 K ohm resistor to limit the amount of current avoiding the LED burnt out.

When the temperature sensor senses an object, the data is transferred through data line SDA pin, and the clock line SCL pin is utilised to synchronize all data transfer over the I2C bus. The Ultrasonic distance sensor shown in Fig. 17 has two important pins which are the Trig pin and the Echo pin. The Trig pin is triggered by the ultrasonic sound pulses when an object is detected. Meanwhile, the Echo pin produces a pulse when the previous signal was reflected and received. Both sensors are connected to the NodeMCU.

IV. CONCLUSION

As the global pandemic issues continue to affect the community at a large scale, early prevention has become one of the most focused issue especially at the early stage. The traditional or general way of monitoring human body temperature may no longer be effective in situations where the data is not being kept and properly tracked. Therefore, this project is proposed in order to overcome this shortcoming. The focus of the system that developed in this project is mostly on obtaining the real time data where they are stored and monitored for tracking and evaluation. These useful data obtained in this system includes the body temperature data that bundled with the identity information. These data are pushed to the internet cloud in real time using IoT technology. In this way, the tracking of the potential virus infected person can be easily done online, and notification can be sent instantly. Therefore the spreading of pandemic can be prevented more effectively. Furthermore, compared with most of the body temperature monitoring system on the market, this system also offered a contactless method using QR scanning to avoid any possible virus infection through objects contact. The implementation of this system uses low cost IoT modules and existing cloud technology which comes with a free cost. This result in an overall low cost system and affordable for small merchants to deploy.

A cost efficient IoT based body temperature detection system has been successfully implemented in this work. However there are some weakness in the system which can be further improved. The process of QR scanning and identity information key in consumed some time which might cause a log queue if the merchant is crowded. Furthermore the genuine of the keyed-in information are totally depends on the honesty the person. An improved version of QR scanning which able to automatically grab the mobile phone number able to effectively accelerate the process and avoid fake contact number being obtained.

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