Tracker and Monitoring System for Self-Quarantined Individuals

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***Abstract*—Quarantine has been established as a method to reduce the spread of infectious disease. Ensuring maximum compliance of quarantined individual has been the key to a successful quarantine. Tracking the movement and monitoring of vitals such as temperature can help health officials in their war against infectious diseases such as Coronavirus Disease 2019. The tracker and monitoring of quarantined individual system is developed with this goal in mind. The combination of device and system that carefully tracks and monitors quarantined individuals can be used to alleviate the task of health officials and reduce the risk of an outbreak from developing further.**

General Terms- Wi-Fi, 2G, 3G, IoT, Covid-19, GPS

I. INTRODUCTION

Infectious diseases are dangerous if left unchecked to spread freely in a community. The year 2019 saw the introduction toward the Covid-19 (Coronavirus Disease 2019) virus which originate from Wuhan, China [6]. In the span of less than a year, the infection has managed to cross over borders and infected almost all population of the human race.

In any outbreak of an infectious disease, the main course of action is to locate the source of the infection. Controlling the initial impact of the outbreak is key in reducing the risk of the outbreak spiraling out of control [5]. Quarantine management plays a lot of roles in ensuring that all process in the quarantine is done perfectly. Health official need to also identify their surrounding as quarantine management differs depending on available resources to use [1]. A successful quarantine can be the end of the spreading of infectious disease. Wuhan, China managed to successfully fight Covid-19 through their effective quarantine [4].

There is also the risk of the quarantined individual breaking their own quarantine. The act of quarantine itself can correlate to solitude. The solitude and uncertainty faced by the quarantined individual during their quarantine can trigger an increase in stress [3]. Given the capacity of different individuals to withstand stands also differs, there will always be a likely case of someone breaking their quarantine of experience worsening symptoms due to their weakened mental state.

The exceptional rate of adoption on IT (Information Technology) devices has led to easy access to technology for consumers and organizations. GPS technology that was once used only by military are now made available to the masses. This technology allows for tracking on the location of individual or items [7]. Quarantine individual location and movement can be tracked hence allowing health official to make correct call of action depending on the actions of the quarantined individuals. Furthermore, the technology has become affordable to be made use in most fields [2].

Vital signs are also important in the process of managing the quarantine. Individuals might develop symptoms during their quarantine period. These symptoms are can be used to check the infection level of an individual. Most infectious diseases inflict high fever as the body tries to fight back the infection and ensure the survivability of the host body. Monitoring of quarantined individuals' vitals such as temperature can help health officials to deduce the state of the quarantined individual and offer correct treatments to better cure the disease.

II. RELATED WORKS

The project utilized technology focused on location tracking and temperature monitoring. These technology has been around and has been widely used by many individuals and organizations throughout the globe. There are a few related works that use the concept of tracking and monitoring for different purposes with different methods.

A lot of industry rely on their fleet of vehicle in their daily operation. The need for a vehicle tracking would be the utmost important in order for them to manage their vehicles. A GPS vehicle tracker system was developed at Jakarta, Indonesia. The system has the ability to track the location of the vehicles while also have identify the state of the vehicle using the available accelerometer. The data is made available by being stored in a server [8].

Another vehicle tracker is developed at London, UK. This tracker uses dedicated radio frequency available at London rather than using GPS. The radio frequency have dedicated frequency for each vehicle which allows for individual vehicle tracking. This project is focused on searching stolen vehicle using the location tracking [9].

Monitoring of vitals such as temperature is important in making decisions. A temperature and humidity monitor and control system was crafted by researchers in Yichang, China. The project is touted to be low cost and low interference. The main feature of the project is that the monitor and control system can receive data both using wired and wireless method. The system developed is small and low powered hence allows for easy deployment where temperature and humidity data is needed [10].

Another monitoring device is develop with the specific use of monitoring multiple vitals. This device can obtain vital data remotely and automatically allowing for easy monitoring. The device is coupled with a mobile application. The mobile application can be used to track the data obtained from the device [12].

Lastly is the development of a fully printed wearable vital sensor. This sensor is used for human pulse monitoring. The sensor is made using Ferroelectric Polymer. This high technology sensor is compact, flexible for use and conforms to human skin characteristics that allows for accurate monitoring. The sensor is capable of wirelessly through wireless sensing technology [11].

III. CONCEPT

This project was developed with the sole purpose of serving the community during times of pandemic like the current Covid-19 pandemic. The effects of a poorly manage quarantine can be devastating toward a nation's healthcare. The device and system are designed to facilitate the nation's healthcare reduce the risk of quarantined individual breaking their quarantine. The device and system will work automatically to obtained data from the quarantined individual without the interference of said individual. This allows for the most valid data to be sent towards the health officials without tempering from the quarantined individual.

A. Device

The device is conceptualized to be in the form similar to wearables such as fitness trackers used by fitness enthusiast. The device is to be simple for to use. The health officials will only need to assign the device to quarantined individual. The quarantined individual will only have to wear the device for the period of the quarantine. The quarantined individual should have no means to remove the device and only health officials can remove the device. The device should be low powered and batteries are its source of power. The admin is the only person to be able access the inner working of the device to ensure maintenance.

Figure 1: The concept of the device for the project.

B. System

The system is to be easily accessible on any device. The reason for this is to allow health officials easy access all time to ensure maximum tacking and monitoring. The system is to be web-based as this allows the system to be accessible on every single device that has a web browser such as a laptop and smartphones.

The system should display the data that has been obtained in both in-depth and simple view. The simple view should be in an easily understood format such as graph for quick looks at the patient's data. In depth view should be in a table that shows all the data collected for the health official to make a more conclusive analysis.

IV. METHODOLOGY

The development of the project for both hardware and software uses Rapid Application Development (RAD) model approach. The project was done using RAD model as a way to ensure the completion of the project in its limited time frame while also delivering a prototype that actually fulfills the objective and requirements of the project.

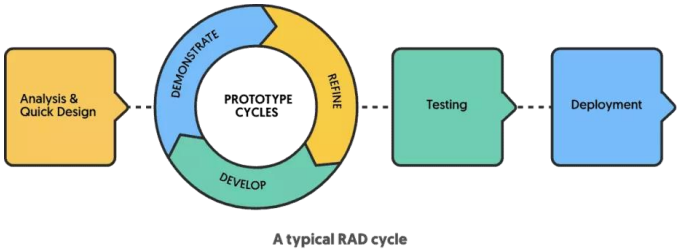

Figure 2: Rapid Application Development Model

A. Analysis and Quick Design

This phase is the very beginning of the project. After determining the objective of the project, analysis on the requirements needed to achieve the project's objective started. A list of software and hardware are also made to determine which can be used for the purposes of the project. A quick design on the hardware and software of the project is also created to give guidance on how the completed prototype should look like.

B. Prototype Cycle

The prototype cycle is a cycle of task that is done repeatedly until a satisfactory prototype that meets the requirement and objective of the project is produced. A prototype is continuously

improved with input given by the supervisor. These improvements include new method to achieve requirements and even the addition of new requirements to further enhance existing requirements. This cycle ends when a finished prototype has been completed and is ready to be used as a final prototype of completed product.

C. Testing

The finished prototype is tested to determine if it works correctly. The test will mostly focused on completing the objective and requirement that has been set out. The testing done can be used to gauge whether the project and the prototype is a success or not.

D. Deployment

The final phase in the development. The finished prototype is used in its intended environment. Corrections are also made to ensure that the prototype can properly work in its intended environment based on the testing results.

V. Device Prototype

The project prototype device is made to test the concept of the project. The prototype device is created using market available IoT (Internet of Things) boards and sensors. This is done to reduce cost while still allowing for the collection of relevant data for the project. The prototype device is not in wearable form as market available boards are not small and flexible enough to be molded into a wearable form.

The prototype device is configured in to forms in correlation to the 2 types of data that needs to be collected. The two forms are thermometer mode and GPS (Global Positioning System) mode. Budget constraints has induced that the two forms use the same board with different sensor link to different connection points. The board that is used is the TTGO T-Call board. The TTGO T-Call is an ESP-32 that come pre-soldered with SIM 800L. This board has Wi-Fi (Wireless Fidelity) functionality and 2G (2nd Generation wireless telephone technology) network capabilities to send data to the web. This board is chosen due to its acceptable pricing and versatility in sending data that is beneficial during the development phase of the project.

A. Thermometer Mode

The prototype device in thermometer mode is capable of recording the ambient temperature and the quarantined individual's temperature. The sensor that is to collect the data while the board uses it Wi-Fi to send the data back to the web. The reason for using Wi-Fi is due to the sparse availability of 2G network that is capable in connecting to web. This is due to rapid improvements in wireless network technology that causes 2G network to be phase out and even 3G (3rd Generation wireless telephone technology) network is heading towards the same direction.

The temperature sensor used is called MLX90614. This sensor is IoT grade sensor capable of taking ambient and human temperature. It is an infrared sensor thus physical direct contact with sensor is not required to get data. The table bellows shows the connection between the TTGO T-Call board with the MLX90614.

Test were done to measure the accuracy of the data obtained from the sensor. The test concludes with 1 pass and 1 fail in terms of data accuracy. The ambient temperature obtained from the sensor are within the average temperature of the Malaysia which is where the test is conducted. The human temperature data obtained however is lower than the average human temperature. A change of code has been done to rectify this but the result yield similar result. The "Fail" in the test could be a faulty sensor or an unsuitable sensor. Due to budget constraints, the problem could not be identified hence it failed to pass the requirement.

Table 1: Test Case for Ambient Temperature Accuracy

Test Case ID	A_D_2
Test Case Scenario	The ambient temperature should be around the average temperature of the surrounding in Malaysia
Test Step	1. View the ambient temperature data from the system 2. Compare to minimum and maximum temperature in Malaysia
Test Data	-
Expected Result	The ambient temperature should be within 21 °C and 31 °C
Actual Result	The temperature shown is within expected ambient temperature in Malaysia
Status	Pass

Table 2: Test Case for Human Temperature Accuracy

Test Case ID	A_D_3
Test Case Scenario	The human temperature recorded should be around average human temperature
Test Step	1. View the human temperature data from the system 2. Compare to average human temperature
Test Data	-
Expected Result	The ambient temperature should be within 35.5 °C and 37.5 °C
Actual Result	The temperature shown is below the expected value
Status	Fail

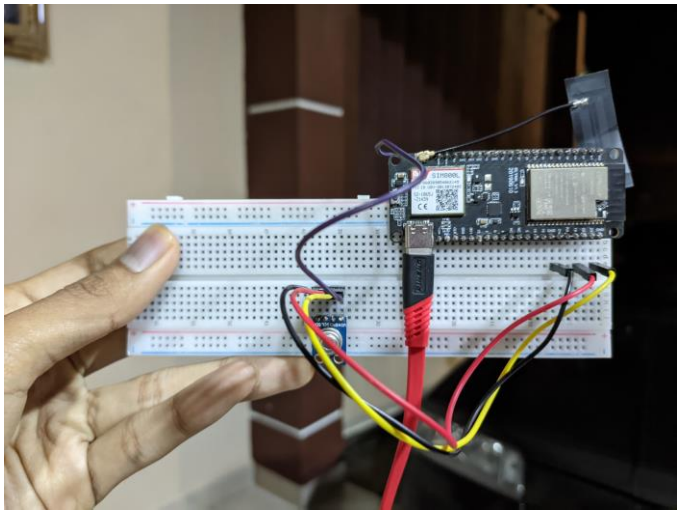

Figure 3: Prototype Device in Thermometer Mode

B. GPS Mode

The prototype device in GPS mode is capable in tracking the location of a person or object as long they are outside. This works perfectly as perfectly as the quarantined individual will need to go out if they were to break quarantine. The GPS data is collected in the form of longitude and latitude. The data is sent to AskSensors system through Wi-Fi where the longitude and latitude can be converted into a visual representation on a map.

The GPS module used for the project is the NEO-6MV2 GPS module. This GPS module is an IoT grade GPS module that allows for GPS tracking functionality for a low price. It suitable for IoT scale project due to its relatively low power draw.

A test was done to determine the accuracy of the module. The module managed to pass the test with great accuracy. This is however granted with the module being used at outdoor environment. The module is unable to get location readings if used in an indoor environment.

Table 3: Test Case for Location Accuracy

Test Case ID	A_D_1
Test Case Scenario	The range of distance the device records compared to the actual location of the device
Test Step	1. View the location data from the system 2. Compare to location search from Google Maps.
Test Data	-
Expected Result	The location displayed is within 150m of the correct location.
Actual Result	The location displayed is around 20m - 40m from actual location
Status	Pass

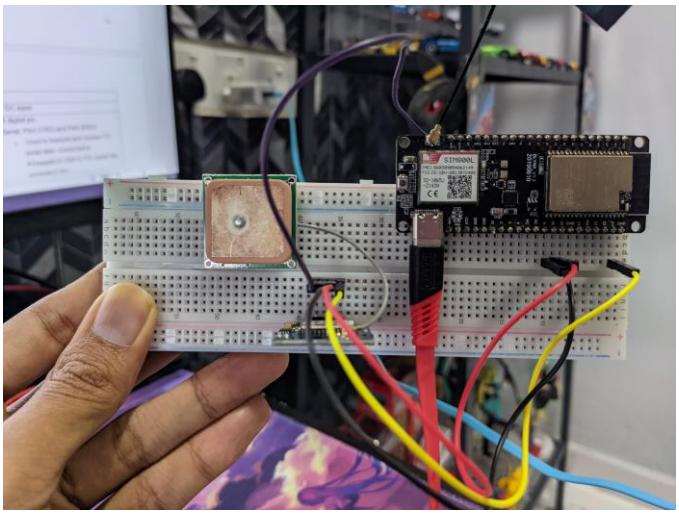

Figure 4: Prototype Device in GPS Mode

VI. Prototype System

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A web-based solution is used for the prototype system that is developed. The system uses HTML (Hypertext Markup Language), CSS (Cascading Style Sheets) and PHP (Personal Home Page) as well as a link to AskSensors to enable it to access

the location data. The system employs different pages to better organize the different data that is available to be viewed by the system. The system can be access by typing the URL (Uniform Resource Locator) of the system.

A. Home Page

The template is designed so that author affiliations are not repeated each time for multiple authors of the same affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization). This template was designed for two affiliations.

The home page can also be called the index page. This is the main page that will be displayed whenever health officials access the system through the URL. This page will display the information regarding the quarantined individual. These information are only basic information that is required by the health official to make an analysis on the quarantined individual. The quarantine location of the quarantined individual is also stated to allow for the health officials to ensure that the individual does not break their quarantine.

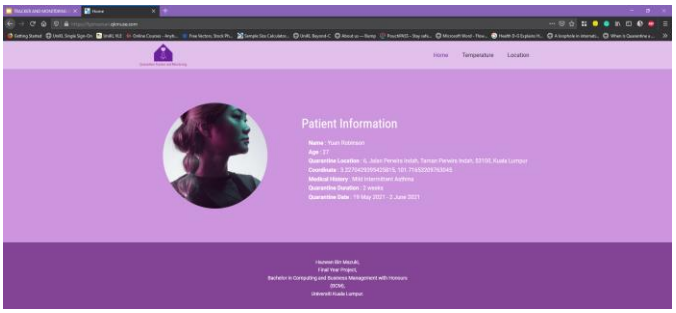

Figure 5: Home page of Prototype System

B. Temperature Page

The temperature page displays the temperature readings obtained by the prototype device worn by the quarantined individual. The temperature data is displayed in Celsius format. The page will display both the simplified and in-depth view on the temperature data obtained.

The simplified view of the temperature data is shown in line graph format. The graph will display only 30 of the most recent readings that the prototype device has obtained. This allows for quick view on the quarantined individual's temperature and does not overwhelm the health officials with too much data.

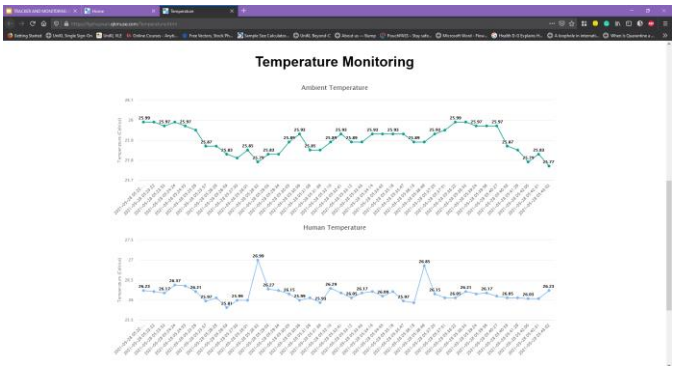

Figure 6: Graph of Quarantined Individual Temperature on Temperature page of Prototype System

The in-depth view of the temperature data is shown in a table consisting of all the temperature readings obtained from the prototype device. Making all the readings available allows for the health officials to make a greater deduction on the state of the quarantined individual and form a correct analysis catered towards their condition.

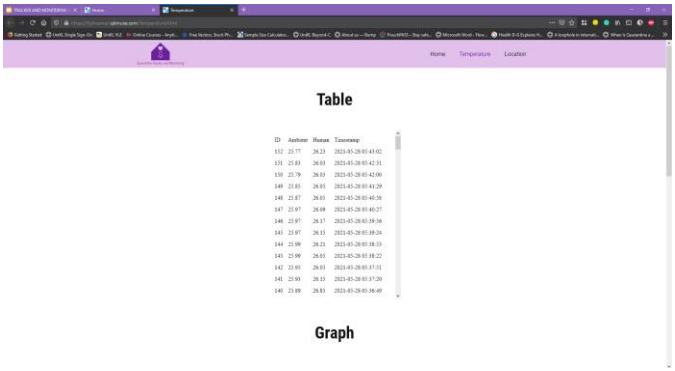

Figure 7: Table of Quarantined Individual Temperature on Temperature page of Prototype System

C. Location Page

The location page is responsible on displaying the current location of the quarantined individual as well as the travel history of the quarantine individual. The map relies on the service of AskSensors to work. This requires a login before anyone can access and view the map. The map is capable of viewing current location as well as previous location that the quarantine individual visited.

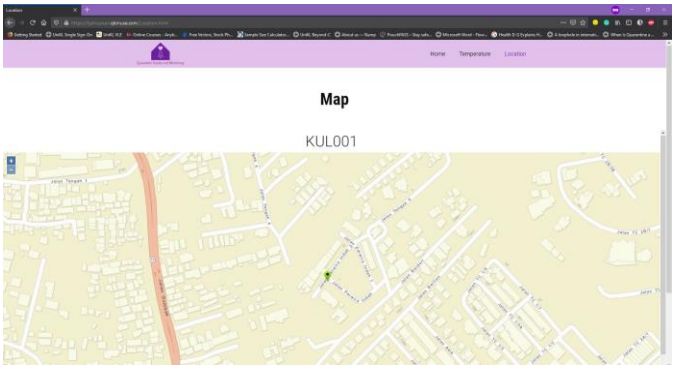

Figure 8: Location page of Prototype System

VII. CONCLUSION

The proposed Tracking and Monitoring of Quarantined Individual System focuses on assisting health official in their combat on infectious disease such as Covid-19. The device and the system work together in unison to help the health officials monitor any quarantine individual. Although this system was developed with monitoring from house quarantine, it can be used even in other places as long as there is a need for monitoring on individual vitals and tracking of individual location especially for those who are more prone to break their quarantine and ran away from the quarantine location.

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