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IoT-Based Portable and Tracking Device for Children Safety

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Abstract: Recently, there has been a drastic increase in crime rates, especially the missing child cases. The children while growing up may be premature in the way they act and face many safety issues such as being abducted in crowded areas and social bullying. Besides, the harassment of strangers has deep effects on a child's physical health. At the moment, most of the portable tracking devices available today are only focused on providing the location and activity of the children. However, lacks the health and alert notification system. Therefore, an IoT-based portable and tracking device was developed to help parents to monitor their child's physical health such as heart rate, beat per minute (BPM) and blood oxygen saturation (SpO2), as well as to track their location in real-time with the alert notification. The alert notification can be sent automatically through email and push notification from the Blynk IoT application in the smartphone when the child's situation whether in abnormal condition. The system detected abnormal conditions for heart rate in the range of <60 BPM or ≥99 BPM. While values of blood oxygen saturation (SpO2) is < 95 %. The system consists of an ESP32 Microcontroller, heart rate pulse sensor and oximeter module (GY-MAX30100), a global positioning system (GPS-NEO6M), lithium battery 3.7V, Blynk as a cloud server and the internet. With the usage of Internet of things (IoT) technologies, the number of missing child cases can be minimized. The system was developed successfully with a prototype of a watch strap and Blynk mobile application which allows the parents to monitor their children in real-time.

Keywords: Heart Rate, Blood Oxygen Saturation, Portable and Tracking Device, Blynk Iot

1. Introduction

Nowadays, the crime rate [1] and social bullying have increased among adults as well as children [2]. Safety issues have become an important part of life, especially for children at risk who are unable to be monitored when they are at school or in crowded areas [3]. The need for safety among the children to be free from troubles and dangerousness becomes the main concern of the parents. Thus, a portable

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and tracking device is necessary to be developed to monitor the children, so that parents can easily track their children's well-being [4]. Most of the portable tracking devices available today are only focused on providing the location and activity of the children [5], however, lack an alert notification system. With the usage of Internet of Things (IoT) technologies, the portable tracking and monitoring device can be integrated with the alert notification system where it can be remote and monitor devices over the internet via the smartphone [6]. To make sure the children are in healthy and safe conditions, the portable device can be improved by providing a sensor that can detect the heart rate, beat per minute (BPM), and blood oxygen saturation (SpO2) condition [7].

In this project, the IoT-based portable tracking device for children's safety was designed and developed to improve the existing functionality of portable tracking devices. It was equipped with sensing element such as a heart rate pulse sensor and oximeter module for monitoring the user's health; an alert and push notification through smartphone and email, the GPS module, which display the exact location (latitude and longitude) of the user on the google maps in real-time. The graphical user interface (GUI) of the Blynk IoT application displays the health condition such as heart rate and oxygen level, as well as the location of the user on the smartphone or mobile phone.

2.0 Methodology

2.1 Overview of the system

An overview of the IoT-based portable tracking devices system for children's safety that was developed in this project is shown in Figure 1. It comprises of ESP32 Microcontroller, GY-MAX30100 heart rate pulse sensor and oximeter module, GPS module, Lithium battery 3.7 V, Blynk cloud as a server and the internet. Meanwhile, when the children wear this portable device, the parents can monitor their child's physical health such as heart rate, beat per minute (BPM) and blood oxygen saturation (SpO2), as well as track their location in real-time with the alert notification from the android mobile application. The portable tracking device was designed and developed with an alert notification, which can be sent automatically through push notification and email to the Android smartphone. It is also able to be used in different situations, either for indoor or outdoor zones. If the child is in an indoor area, then the parents can easily monitor the children through the smartphone Blynk IoT application by connecting the house's internet. Whereas, if the child is in an outdoor area, then the parents may open a hotspot of a smartphone with a Wi-Fi connection to monitor the children.

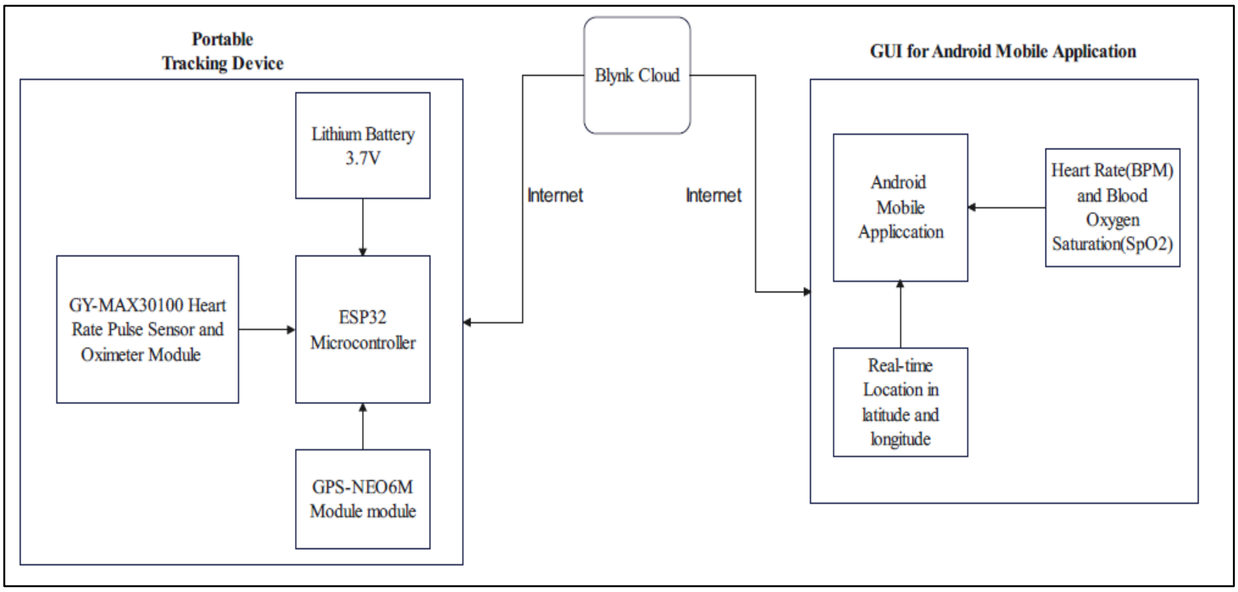


Figure 1: Overview of the IoT-based portable tracking device system

2.2 Flowchart of system development

Figure 2(a) shows the flowchart of an IoT-based portable and tracking device System and Figure 2(b) depicts the flowchart of the Blynk Mobile App System. Firstly, power on the portable tracking device. Then, the ESP32 microcontroller will automatically connect to the network and Blynk IoT application in the smartphone. The system can be categorized into 2 parts which are from the parents' side and children's side. From the parents' side, they need to download, install and open up the Blynk IoT app. Then, key in a username and password before logging into a Blynk IoT app. If login is successful, it will present the graphic user interface (GUI) of the portable tracking device system which displays the health condition such as heart rate and oxygen level, as well as the location of the user on the smartphone. From the children's side, they may wear this portable tracking device when going to school or crowded areas. The device will start operating by reading a GPS module, when the GPS module detects a location, it will generate a coordinate in latitude and longitude. Otherwise, it will wait until it receives a signal to generate data. Then, it will follow by reading the heart rate (BPM) sensor. According to health regulation [8], the normal detection range of heart rate, and beat per minute (BPM) which are between (60 -99) BPM while the normal detection range of blood oxygen saturation (SpO2) condition is between 95-99 % [8]. Occasionally, the SpO2 levels indicate our body's red blood cell capability to transport oxygen throughout the body. If the oxygen saturation is less than 95%, it represents the body's inefficiency in transporting the oxygen. People with chronic diseases like heart failure, heart disease and asthma need to monitor their oxygen saturation to avert fatal risks constantly [9]. If the heart rate level is < 60 BPM or ≥99 BPM, Blynk IoT will send email and push notifications to Android mobile phones and it will display the children's situation is abnormal. Meanwhile, it will further by reading the blood oxygen saturation level. If the blood oxygen saturation level is < 95%, Blynk IoT will send email and push notifications to Android mobile phone and it will display the children's situation as abnormal.

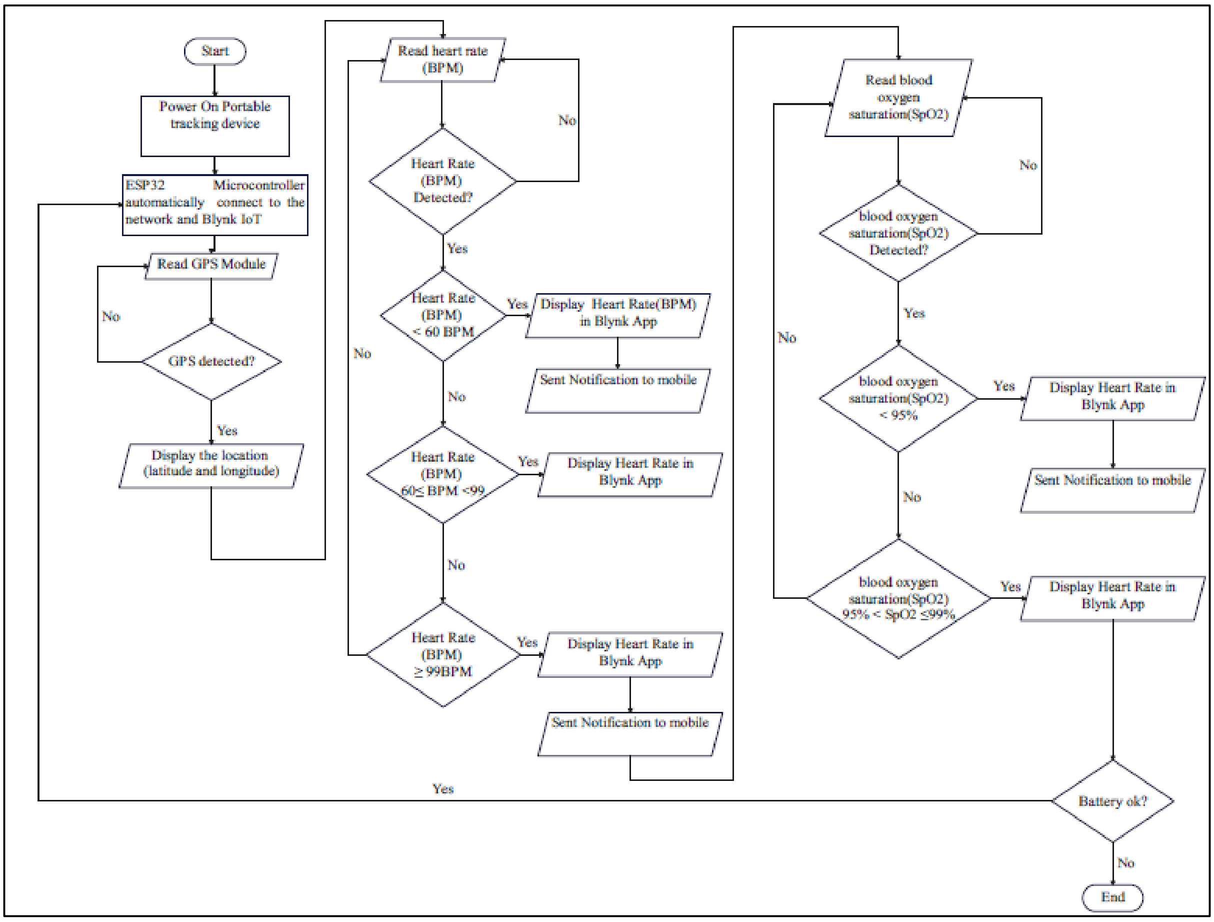


Figure 2(a): IoT-based portable and tracking device System

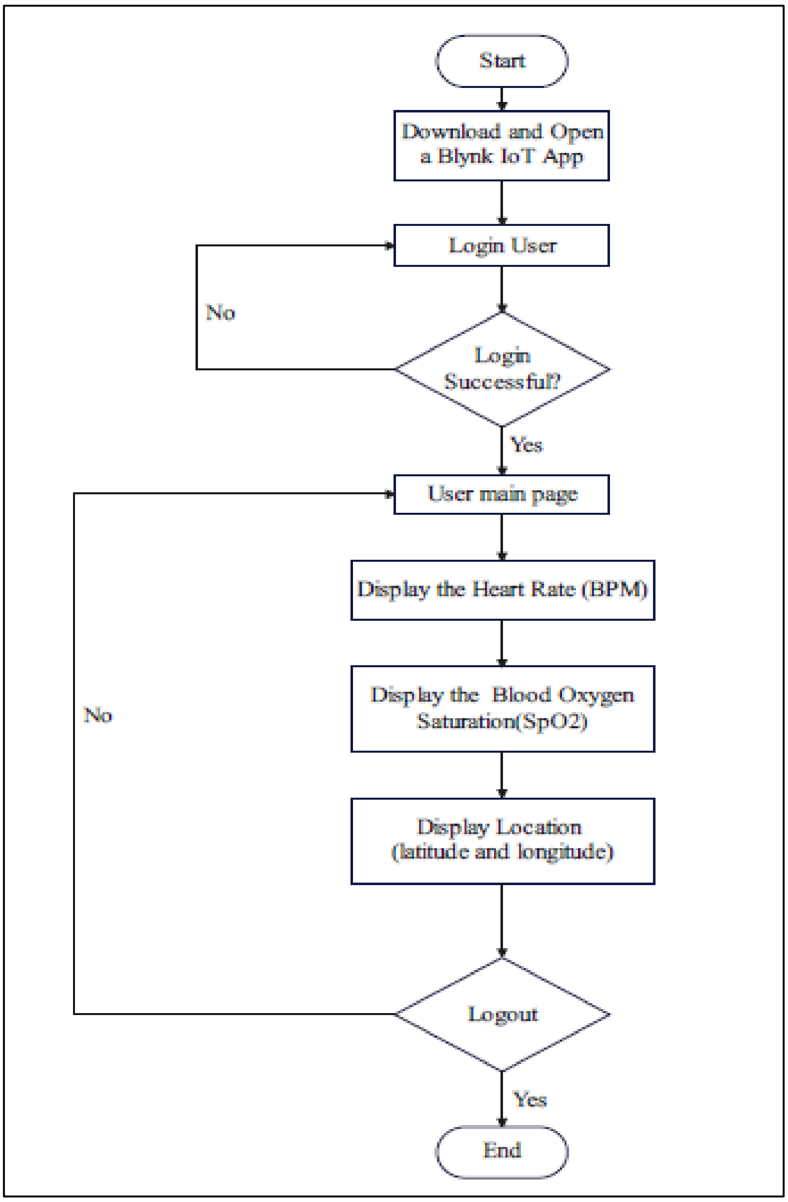


Figure 2(b): Blynk Mobile App System

To confirm the values of heartbeat and blood oxygen concentration achieved in this project were trusted and reliable. The values obtained in this project were compared to the existing oximeter device for comparison. In this case, the tracking and portable device were tested 10 times to estimate the accuracy of the data obtained and the relative error in percentage % was calculated using equation 1 [10].

$$\%\text{Relative Error} = \frac{\text{Expected Value(Portable Device)} - \text{Actual Value(Existing Device)}}{\text{Actual Value(Existing Device)}} \times 100\% \quad \text{Eq1}$$

Figure 3 shows the actual circuit connection of the IoT-based portable and tracking device system. The circuit is drawn and illustrated by using Fritzing software. It comprises of Arduino NodeMcu IoT ESP32 Microcontroller, GPS module with antenna, GY-MAX30100 heart rate pulse sensor and oximeter Module and also lithium battery with 3.7V. For the case of determining the coordinate location, the data location retrieved from the GPS module of the device using the Blynk IoT application in this project was compared to the coordinates produced by Google maps. Hence, it is expected that the generated location in real-time of the developed device was accurate.

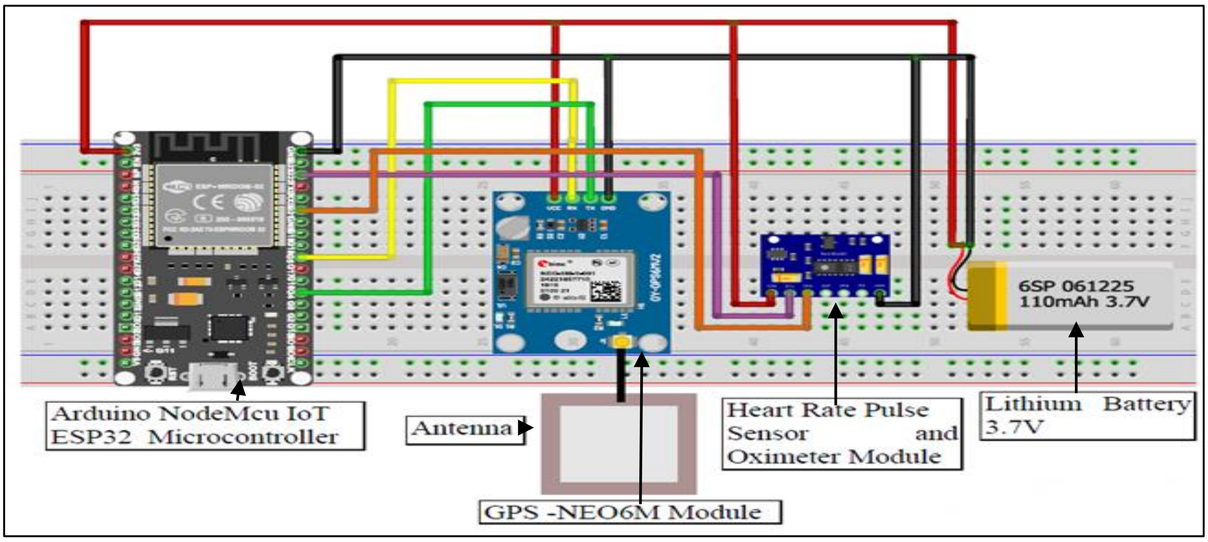
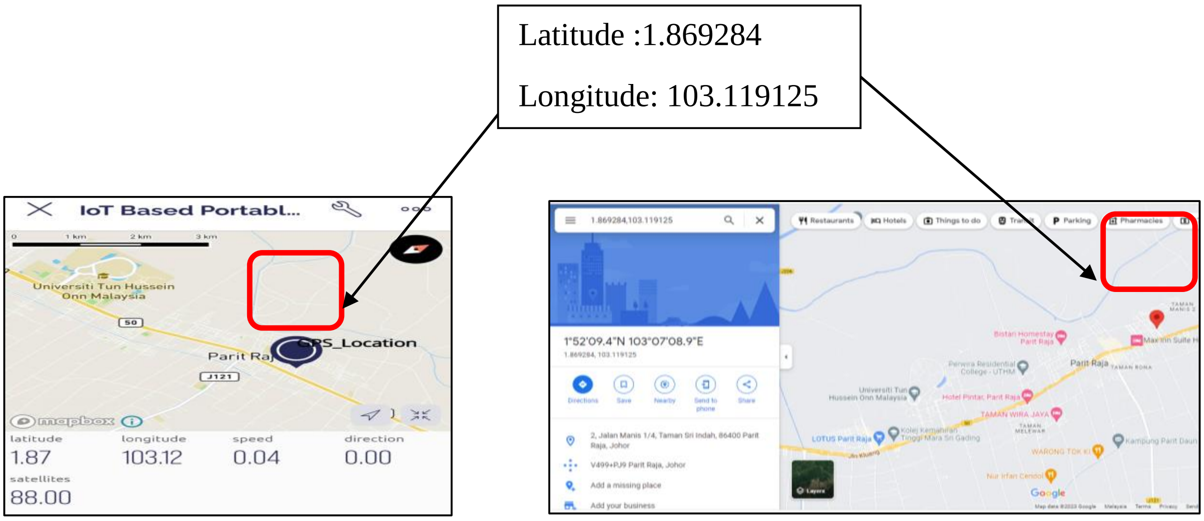


Figure 3: The actual circuit connection of the IoT-based portable and tracking device system

3. Results and Discussion

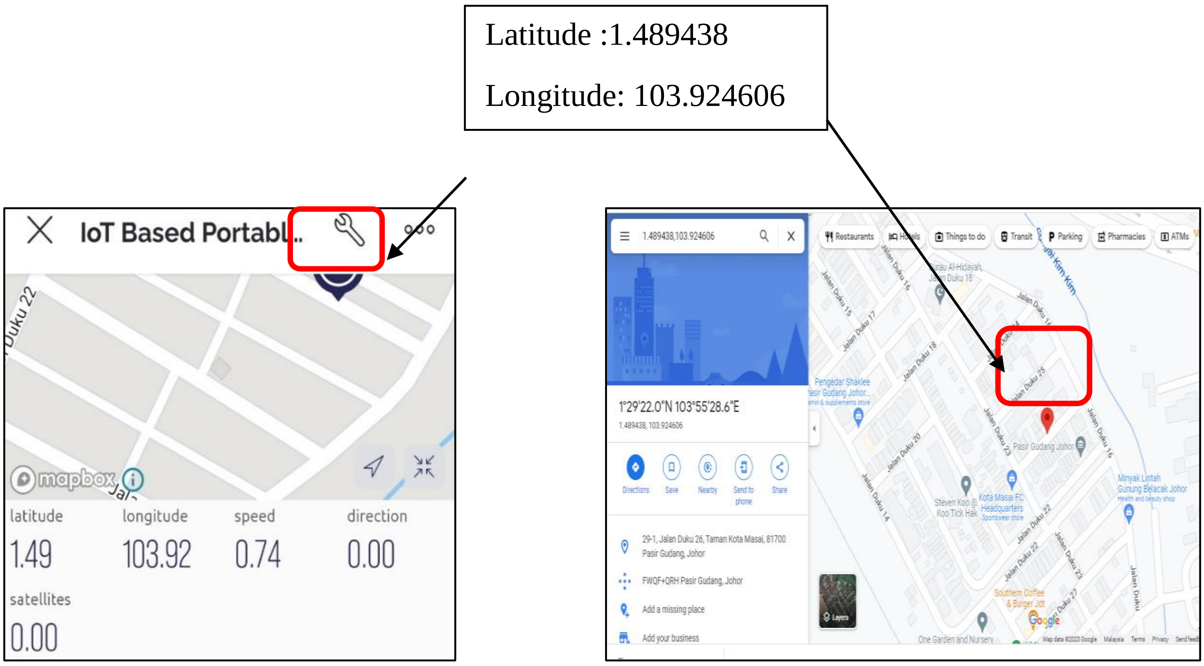
3.1 GPS module (GY-NEO6MV2)

The results from GPS data retrieved from the portable tracking device and Google Maps are shown in Figures 4 and 5. Figure 4 (a) shows the image of data location from the portable tracking device and Figure 4 (b) an image taken from the Google Maps of location A. Results show that both give almost the same latitude at 1.87 and longitude at 103.12, only with different decimal places. Figure 5 also shows the latitude at 1.49 and longitude at 103.92 of location B of the portable tracking device, which is almost similar to Google Maps with different decimal places. These results have confirmed the data accuracy obtained for the location produced in this project.



(a) (b)

Figure 4(a): The data location retrieved from the GPS module of the device based on the Blynk IoT application and Figure 4(b): GPS Location on Google Maps in Location A



(a) (b)

Figure 5(a): The data location retrieved from the GPS module of the device based on the Blynk IoT application and Figure 5(b): GPS Location on Google Maps in Location B.

3.2 Result for GY-MAX30100 Heart Rate Pulse Sensor and Oximeter Module

Table 1 and Table 2 show the average reading for the heart rate (BPM) and blood oxygen saturation (SpO2) in percentage, (%) monitoring system among 10 children who are comparable in terms of age and gender but differ weights and heights. The vital measurements of the children were compared to obtain the average readings with an existing pulse oximeter for the heart rate (BPM) and blood oxygen saturation (SpO2). To verify the efficacy of the sensors, the measured data were compared to the commercial products or existing pulse oximeter device that has been used in testing and calibration for the level of heart rate (BPM) and blood oxygen saturation (SpO2) condition.

According to the average reading of heart rate (BPM) and SpO2(%) measurement among 10 children the results show that the portable tracking device has a relative error with an average of ± 0.9 as compared to the existing oximeter. This indicates that the portable tracking device was unstable in determining the data from children may be due to the position of the sensor during measurements. Results show the portable tracking device is capable of detecting various conditions either normal or abnormal as the range can be referred to in the methodology part.

Table 1: The average reading of heart rate (BPM) measurement among 10 children

Children	Heart Rate (BPM)		Relative Error (%)
	Portable Device	Existing pulse Oximeter Device	
Children 1	148.05	149.05	0.67
Children 2	60.58	61.58	1.65
Children 3	58.50	59.60	1.88
Children 4	93.75	94.10	0.37
Children 5	88.50	89.50	1.13
Children 6	149.08	150.09	0.68
Children 7	112.50	113.75	1.11
Children 8	133.75	134.50	0.56
Children 9	112.50	113.15	0.58
Children10	135.80	136.36	0.41
			Average =$\pm$ 0.90

Table 2: The average reading of blood oxygen saturation, (SpO2), (%) measurement among 10 children

Children	Blood Oxygen Saturation, (SpO2) (%)		Relative Error (%)
	Portable Device	Existing pulse Oximeter Device	
Children 1	95	96.33	1.40
Children 2	95	96	1.05
Children 3	95	96	1.05
Children 4	93	94.50	1.61
Children 5	94	93.33	0.71
Children 6	93.33	92.78	0.59
Children 7	91.67	90.85	0.89
Children 8	95	96	1.05
Children 9	94	93.75	0.27
Children10	92	91.67	0.36
			Average = $\pm$0.90

3.3 Mobile application and alert notification

Figure 6 illustrates the output result of an IoT-based portable tracking device. It is a graphical user interface (GUI) obtained from the Blynk IoT application. It integrates a reading of the GY-MAX30100 heart rate pulse sensor and oximeter Module and GPS module. After turning on the portable tracking device, the GY-MAX30100 heart rate pulse sensor and oximeter module will detect the heart rate (BPM) and blood oxygen saturation (SpO2) of the children as well as their location in real time. At the first of GUI, it shows results of the current BPM value of 61.49 indicating that the children are having a normal heart rate. Meanwhile, The SpO2 value of 95 represents that the children are having normal oxygen. The second part shows the overall graph obtained for BPM and SpO2 for every minute's gap. On the other hand, the location of children also shows on Google Maps in the mobile application as well and it can generate a coordinate in latitude and longitude. The latitude is approximately 1.87 ° while the longitude is approaching with a value of 103.12 °. Figure 7 shows a notification received in email while Figure 8 illustrates a push notification from the Blynk IoT application after the detected by the heart rate pulse sensor and oximeter module.

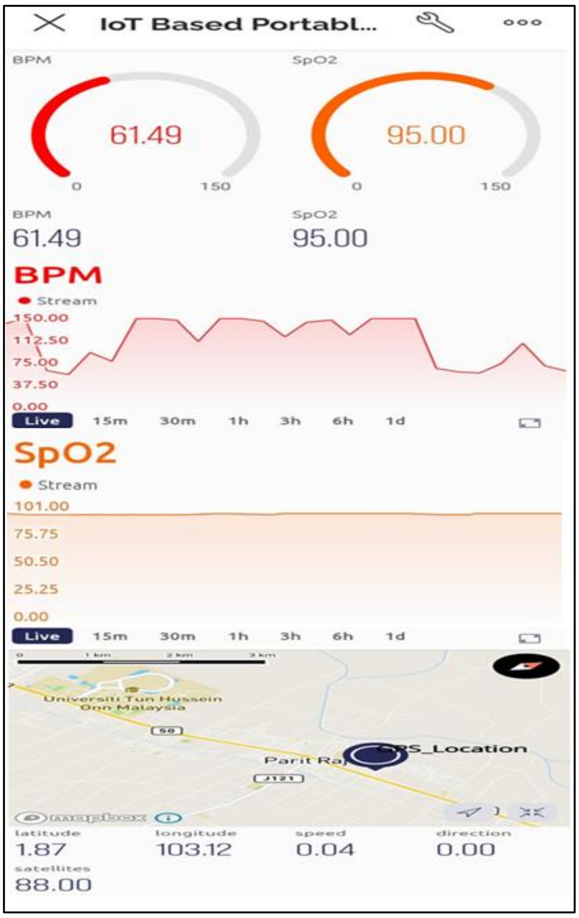


Figure 6: The graphical user interface (GUI) output results from Blynk IoT application

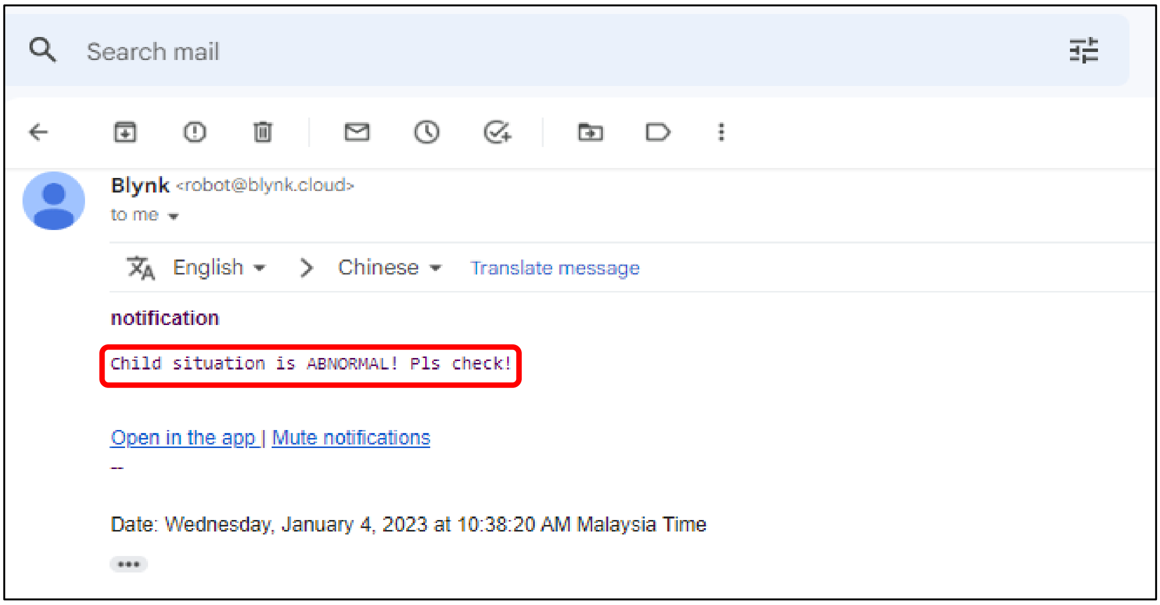


Figure 7: Notification received in Gmail

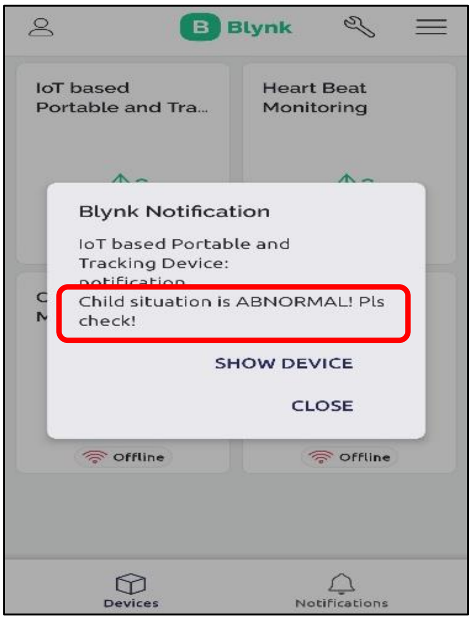
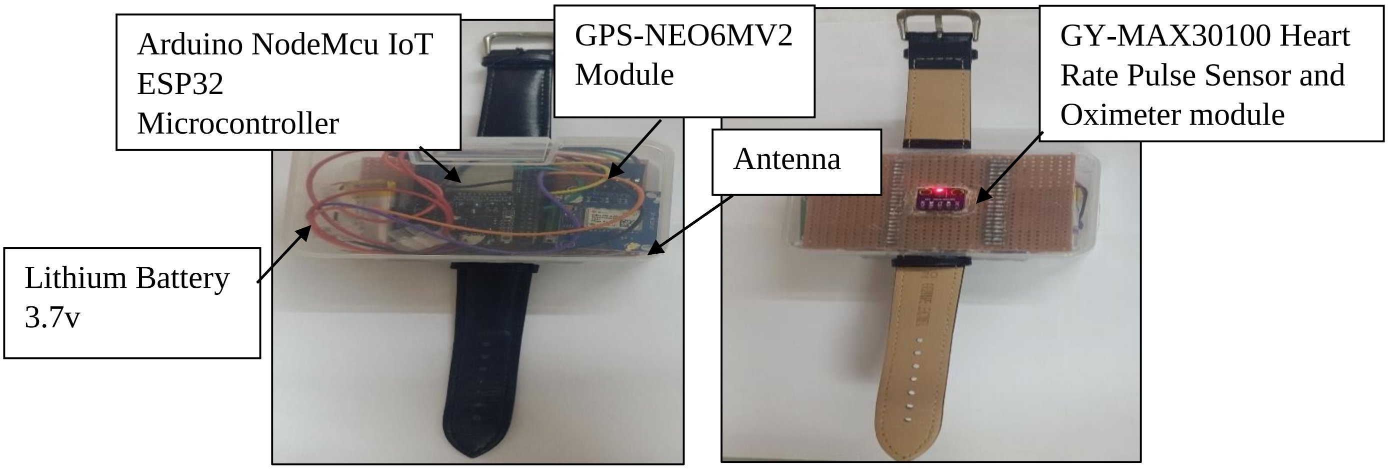


Figure 8: Push notification of Blynk IoT application in Android smartphone

3.4 Project Prototype

Figure 9 shows the watch strap integrated with a tiny casing for the IoT-based portable tracking device. The dimensions of this portable tracking device are 8.8cm (L) x 6.4cm (W) x 2.5cm (H) and it is light and convenient to wear. The total mass of a portable and tracking device with a battery and casing was 102g, where gram (g) is a unit of mass.



(a) Front-end view (b) Back-end view

Figure 9 : (a) Front-end view and (b) back-end view for the Project Prototype

4. Conclusion

In conclusion, an IoT-based portable tracking device has been successfully developed in this project. The objective has been successfully achieved which is to design and build a real-time an IoT portable tracking system for monitoring children. The existing device such as a smart watch available in the market lack with an alert notification. Therefore, an IoT based portable tracking system was developed with the mobile notification system integrated with sensing element to enhance the children safety. Nevertheless, the advantages of having this portable tracking device can be reduced the cause of the missing child cases. In addition, the developed system features of the function should synchronizing with the real-time data obtained from the serial monitor and Blynk IoT. It can be concluded that an IoT-based portable tracking device developed in this project can ease the parents to monitor their children in real time. Thus, can potentially minimize the missing child cases and monitor children's health.

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