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Developing Internet of Things (IoT) Device for Saving Children from Being Left in a Car

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ABSTRACT

Recently, there have been news reports about the death of children left in cars or kindergarten vans. This paper presents a device that can prevent the death of the children by using IoT devices and mobile applications. The researchers have an objective of innovating a way to notify overseers when a child has been left in a van by using a mobile application and to allow parents to track their own children by using an IoT device and mobile application. We placed a device in a car that would send data to a cloud server that we created and used a mobile application to watch the webcam in the car, edit information of passengers, and receive the data from the device. We have tested the system from 1st Jan to 31st Jan 2021 with 30 testers and received satisfaction assessments to measure performance and feedback of testers to improve this device. For the result, we made two parts of satisfaction assessment, which are usefulness, and field of use, containing 7 questions. The results show that this device has satisfaction's mean($\bar{x}$) = 4.20, standard deviation (S.D.) = 0.60, and level of satisfaction is vary.

Keywords: Internet of Things; Innovation; Mobile application; Preventing death of children; Saving children

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1. Introduction

According to the news from 2014-2020, children have been left behind in car 129 times and 6 died [1-4] because of the negligence of drivers and teachers who failed to check to see if there are children remaining in the car or not.

We developed a system that will scan for children left in the car or van by using RFID. The system would then notify the overseer to let them know that their child is being left in the car. Additional functions are: tracking location, checking the status of the car, and seeing the information of the passengers in the car. All these functions are used by IoT devices and applications.

Therefore, this research study for Developing Internet of Things (IOT) devices for saving children from being left in the car and the objective of this case study are: innovating IoT device and mobile application for helping kids, notice overseers when the kid still in the car by using mobile application, and parent can track their own children by using IoT device and mobile application.

2. Literature Review

This section, included the information of the interested relatives from other sources of research by exploration. This information gives the fundamental concept and common problems of the device and mobile application, which can research for the knowledge and process that can develop and improve in further. Moreover, it can analyze the advantages and disadvantages of improving the device.

2.1 Lampang technician student created anti children forgotten in van device

Two students of Lampang Technical Collage have explained about the operation of the device that in the car, there is a circuit box for controlling the whole system by a computer including motion detected sensor. When the system starts working, if the sensor is detected, it will send a signal to the controlled box and the controlled box will operate the system to make a siren and scroll down the car's window automatically to let people near the car can help children that be forgotten. The system will start when pulling off the key from the car and lock the car. If the sensor detected a motion in the car, the system would operate in 30 seconds by making a siren and send SMS including car location to overseers for five people [5].

2.2 Anti children forgotten in van device with notification signal

Professor and student of Lampang Technical invent the device that helps children left behind in the car by using motion detected sensor. The device started when to lock the car immediately within 15 seconds and if the sensor detected life being or motion in the car, it will siren and flash signal at the car and send an SMS that has a message "Help me" to five phone numbers that recorded in the device with show the car location in the message. Otherwise, the car will open the door automatically to let overseer/parents/other people can help children in the car. And the other device is Carbon Dioxide Controlled in car Device. This device operates automatically when detected children are stuck in the car and measure Carbon Dioxide value. If the value is higher than 1,000 ppm, the device will let the speaker notice that children stuck in the car. If it noticed 3 times and the car still closed, the fan will start working and the car's window will open to let the air come inside the car for bleeding air [6].

2.3 OVEC Ka car kids alarm

This device is an invention caused by an incident of a student stuck in the car, unable to help him/herself out of the car causing the loss of life. That's why came up with the idea of creating a child alarm in the car based on the principle of detecting movement inside the car. After the driver turns off the ignition and exits the car for 30 seconds, the system starts to detect movement in the passenger compartment. When it detects the movement, there will be

a process of working into 3 parts at the same time: order to lower the window for 2 seconds, alarm with siren alarm sound, and send an SMS containing GPS coordinates to a mobile phone. However, if users use a smartphone device, they can view the location immediately [7].

2.4 The monitoring alarm and prevent children from being left on parked vehicle

This project's device PIR module, RFID module, photosensor, and GSM module. Process of the device: RFID module recorded passenger's tags and count number of the passenger, when arrived the destination, passengers went out of the, if RFID module count number of passenger get in the car and passenger get out of the car are not equal, the car's door will not lock, when the car is locked, PIR module and photosensor will start to detect life being in the car, if detected, the device will make a siren alarm and send an SMS message to overseer's passenger by using GSM module. And this project research about the accuracy of 3 modules which are: PIR module, RFID module, and photosensor, test by detected the same subject 50 times. And the result has shown that the PIR module and RFID module detected 49 of 50 times and photosensor detected 48 of 50 times. It shows that the PIR module and RFID module are more accurate than photosensor [8].

2.5 Driver Alarm for Preventing Children from being Left in Car

A driver alarm for preventing children from being left in a car comprises a power device, a voltage measuring device, an inputting device, a prompting device, and a controlling device. The power apparatus has a plug, which can be inserted into a cigarette-lighter socket in the car to become a power source for the driver alarm. The voltage measuring device is used to measure the voltage of the cigarette-lighter in the car, the voltage rises when the car is started up and the voltage declines when the engine is turned off. The voltage measuring device reports to the controlling device about voltage rising or voltage declining. The inputting device is designed for a driver to report to the controlling device about whether children are in the cars or not. The promoting device is used to warn the driver that there are children inside of the car when the car is started up or when the engines are turned off. Based on the information provided by the voltage measuring device and the inputting device, the controlling device follows designed program to control the prompting device to warn the drivers that there are children inside of the cars when starting up the car and when turning off engines [9].

2.6 IOT Safety System to Stop Children from Being Left in Hot Vehicles

The components of the proposed system include: a GPS-enabled child seat pressure pad/temperature sensor vehicle transponder, wearable child/parent/caregiver transponders, and home/caregiver/work base stations. Through a signal chain, the system is connected to a smartphone app that resides on the phones of parents, caregivers, and other designated caring observers. Through the app, the functions of the transponders are assigned. The locations/ambient conditions of the transponders are then tracked and analyzed. The child/parent transponders have long range Bluetooth communication with both the home/caregiver/work and vehicle child seat pressure pad/temperature sensor base stations. The home/caregiver/work and vehicle child seat base stations have built in cell system access. All devices directly communicate with the smartphone app [10].

2.7 High-tech alarms go off when kids are left in hot cars

The Sensor Safe clip attaches to the seat's harness system and syncs to a smartphone to provide alerts when a child is left unattended, or the child's temperature

becomes too hot or too cold. Alerts are also given when a child has been seated too long, or when children unbuckle themselves when the car is moving. The Elepho eClip Baby Reminder is a small alarm that can attach to a car seat belt, regular seat belt, or diaper bag strap and syncs with a smartphone through Bluetooth or a key fob to send alerts if a child is left in a car. It activates when drivers walk more than 15 feet from the car without a child. If the driver moves further away, pre-designated contacts will begin receiving text messages about a child left behind [11].

2.8 Conclusion of Review

My research from all articles, mostly used similar components and functions. But our research has a different component to innovate a device that is more useful than other devices by adding precious devices such as: camera module, RFID module, Webcam, and OBD II module. By adding these modules, it made our device more accurate and functional as shown in Table 1. Also, we included a mobile application to view and control a IoT device that attached in a car.

Table 1. Overview of devices.

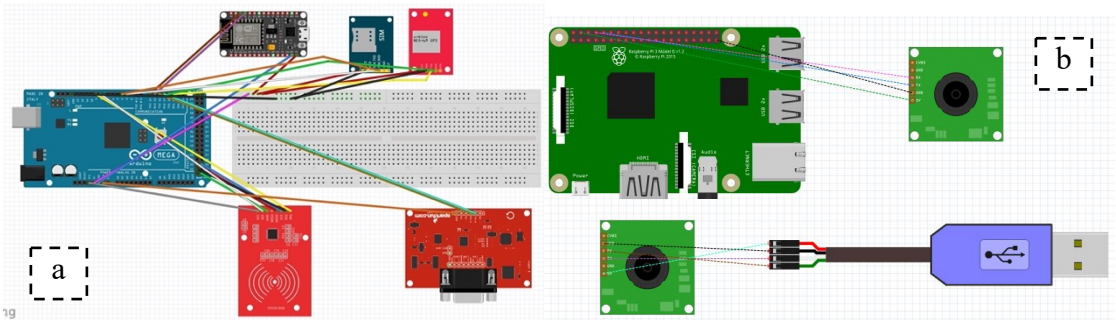
	Arduino Mega (16 Mhz)	OBD II Module (Baud rates from 38 bps to 10 Mbps)	Camera Module (Max. Frame Rate: 30fps VGA) (Pixel Coverage: 3.6um x 3.6um)	GPS Module (Navigation Update Rate 5Hz)	3G Module (Support the GSM/GPRS four frequencies, including 850, 900, 1800, 1900Mhz)	Ultrasonic module (Frequency: 4000 Hz)	NodeMCU Esp8266 (Wi-Fi Built-In: 802.11 b/g/n)	RFID Module (Operating Frequency: 13.56MHz)	Mobile App	Result
Model 1	✓	✓	✓	✓	✓		✓	✓	✓	- High accuracy - Live Cam - Car location - Car status - Passenger info.
Ref A [5]	✓					✓	✓			- Only movement detected - Car Alarm - Send SMS
Ref B [6]	✓					✓				- Only movement detected - Car Alarm
Ref C [7]	✓			✓		✓	✓			- Only movement detected - Car Alarm - Car location - Send SMS
Ref D [8]	✓				✓			✓		- Use camera mainly - If signal lost, it cannot send data
Ref E [9]	✓								✓	- Use voltage measuring device - Plug in cigarette lighter socket - Can check child in the car only
Ref F [10]				✓					✓	- Bluetooth communications - Track location -Car Alarm
Ref G [11]				✓					✓	- Bluetooth communications - Send SMS - Car location

3. System Design

This research combines with two mainly parts which are: IoT devices and application. We expect to study about Arduino system and innovating new IoT device and mobile application to help a kid that is left behind in the car with the knowledge that we learned from the university. The design will be considered on the safety as well as aesthetically to ensure that the operators of this model will be safe and clearly understand the operation of IoT devices and mobile applications system. And make the prototype to see how the system is running 100% or not.

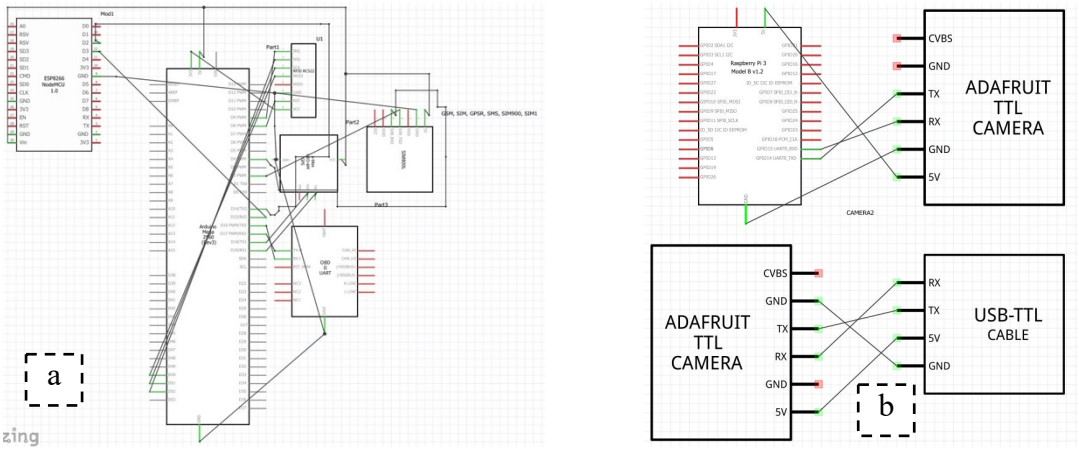
3.1 IoT's device concept design

This research combines with two mainly parts which are: software and hardware. To design the concept design, we used Fritzing application to choose components and design the IoT device as shown in Fig. 1a and Fig. 1b. For figure 1a is a circuit of Arduino Mega and Fig. 1b is a circuit of Raspberry Pi3 which two circuit will connect to each other with NodeMCU esp8266. In Fig. 2a and Fig. 2b, there are same circuit with Fig. 1a and Fig. 1b but show in schematic diagram form. For Fig. 3, it shows a position of each module in a car.



(a) Circuit of Arduino Mega (b) Circuit of Raspberry Pi 3

Fig. 1. The IoT device designed by Fritzing application.



(a) Schematic diagram of Arduino Mega (b) Schematic diagram of Raspberry Pi 3

Fig. 2. Schematic diagram of IoT device.

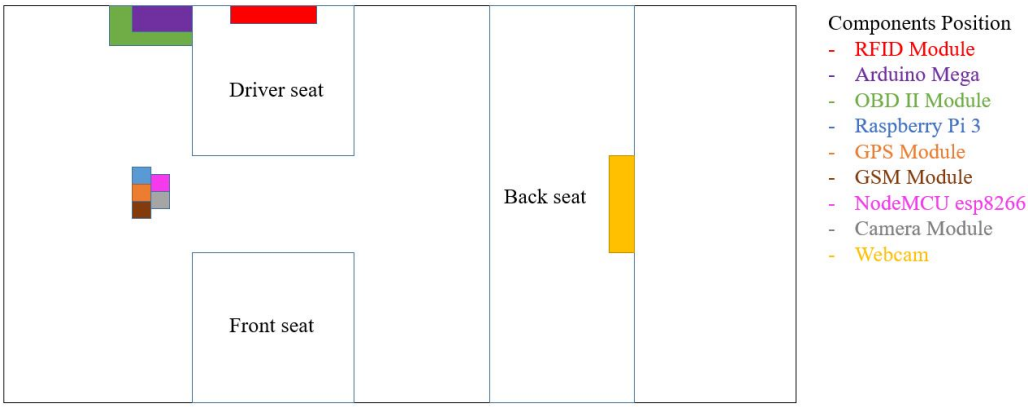


Fig. 3. Position of each module.

3.1.1 Components

The Table 2 represents the estimated research's expense as well as the brand for each component (main components) of IoT device in this project.

Table 2. List of Components.

No.	Device	No. of device	Specification	Cost (Baht)
1	Arduino Mega	1	ATmega328 microcontroller	360
2	Raspberry Pi3	1	Broadcom BCM2837 Processor Quad core A53 (ARM v8) 64-bit SoC	1,590
3	NodeMCU esp8266	1	Wi-Fi Built-In: 802.11 b/g/n	110
4	GPS module	1	Position Accuracy: 2 M and better with multiple good satellite signals	300
5	GSM module	1	Support the GSM/GPRS four frequencies, including 850, 900, 1800, 1900MHZ	380
6	Camera module	2	Resolution: 360p	345
7	OBD II module	1	Can use with 2000s car only	2,990
8	RFID module	1	Operating Frequency: 13.56MHz Data transfer rate: maximum 10Mbit/s Length: 1 m.	55

For this research, we used budget about 6,775 Baht to make this device. For this budget that we invested to this device, we seen that it's worthy because this device developed to help child has stuck in the car and give a safety to their overseers. Also overseers can be confident that this device monitor their child all time which mean 100% avoid Child stuck in the car's incident.

3.1.2 Design and develop hardware

To design hardware, we can separate it into two parts are modules that detected life being and Central module which receives and transmits data from the sensor to the application. For detected life being modules, we use RFID module, Camera module, and Webcam to detected life being in the car which 3 modules have difference duty. RFID module has to scan RFID tags and check the number of passengers, Camera module has to capture a picture in the car, and Webcam has to streaming the video inside the car real time. For the central module, we use Arduino Mega and Raspberry Pi3 to control the operation which has to receive and transmit the data from the sensor to the application such as location, speed, distance, etc. Also, the power source of this device is coming from the battery of the car. For all component, we used Technology Acceptance Model Theory

(TAM Theory) to choose and design the device [13].

3.1.3 Process of testing IoT device

For testing device, we attached the device in the car and then let passengers scan RFID tags and get in the car, then the driver drives a car through the route that we set up and check the location in the computer and compare with Google map application every 2 minutes. For GSM module, we tested by using module itself become a Wi-Fi hotspot and check the signal every 2 minute and check that device can transmit the data through the GSM module or not by check the code in the computer which print every time when data transmitted. For camera and webcam, we tested by let camera capture a picture in a car and send to computer and let webcam streaming a video in real time through the computer to check resolution of the camera and webcam and sensitive of camera and webcam.

3.1.4 Testing route

For the route that we use to test the system, we use the route from Thammasat University (Pattaya campus) to Laemchabang 1 Municipality School as shown in Fig. 4. The total distance is 26 km. And drive through these route 1-2 hours in 21 days of January except Saturday and Sunday for testing the device's system.

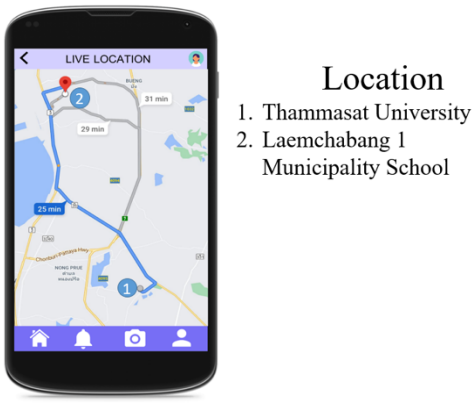


Fig. 4. Route of Testing device's system.

3.2 Application development

The development of "Developing Internet of Things (IoT) device for saving children from being left in a car", The researchers have developed an application with a plan to design and develop the application by using hardware and software for complete the design that we set in the beginning.

3.2.1 Process of design and develop an application

Researchers have designed and developed an application by using System development life cycle (SDLC) which mean division of steps in the process of system development or information technology systems to help solve business problems or meet the needs of the organization, the system to be developed may be a new system development or improvement of the old system. The development of the system is divided into 7 stages.

1. Problem determination: It is the stage of event planning by set the format of the software, estimate development costs, establish guidelines for system development, set time, etc.
2. Analysis: It is a process of finding system requirements and analyze that demand to understand the overview and function of the system.
3. Design: It is a process of designing various software components to meet the needs that have been analyzed.
4. Develop: It is a process of creating a system by programming. According to the design guidelines from the past.
5. Testing: It is a process of bringing the system to test the use that it works properly according to the requirements or not. This test also includes a link test with other relevant software systems.
6. System implements: It is a process of evaluating whether a system has been tested that it is appropriate to use it or not.

7. Maintenance: It is a process that fix or improve the system after tested the program that we created.

3.2.2 Application's hardware

For developed an application, we used smartphone and tablet to develop and improve the system.

3.2.3 Application's Software

1. Firebase: Data transmission for application rendering uses Firebase Real-time Database as a NoSQL cloud database that stores data in JSON format and automatically connects to all devices in fraction of a second. Support work when offline, the data will be stored in Local until back online, it will automatically connect to the data, including Security Rules for developers to design conditions for accessing data for both Read and Write according to both Android and IOS.
2. Netpie: It is an IoT (Internet of Things) cloud platform used to develop and store data of various IoT devices. Researchers have used Netpie to send and receive data between the application and the IoT by creating a Rest API so that the application can. You can retrieve data from Netpie at any time and when updating the data from the IoT, Netpie will update the data and send the latest information to the application [12].
3. Flutter: Through this research, the researcher has chosen to use Flutter in application development because flutter is a tool used to develop cross-platform applications. Allows the researcher to develop an application that can be used for both Android and IOS.

3.2.4 Application testing

The researcher tested the performance of the application by giving a sample of the application trial and giving some satisfaction assessments to measure performance and the level of difficulty to use the mobile application and take the feedback that has been received to improve the application performance.

3.3 Device's system

The IoT & mobile application processes are representing in Fig. 5 in form of flowchart.

3.4 Process of testing device

For testing device, we attached the device in the car and then let passengers scan RFID tags and get in the car, then the driver drives a car through the route that we set up and check the location in the application every two minutes, when arrived at the destination that we desired, let the passengers get out of the car and make two conditions: first, no one left in the car; the device sends the notification to the mobile application that there is no passengers in the car or not and second, passenger left on the car; the device sends the notification to the mobile application that there is a passenger in the car or not and the camera can watch in real-time or not. For car status, we tested by use a command in the mobile application to check the status of the car. The processes of testing device follow the conditions as shown in flowchart in Fig. 5.

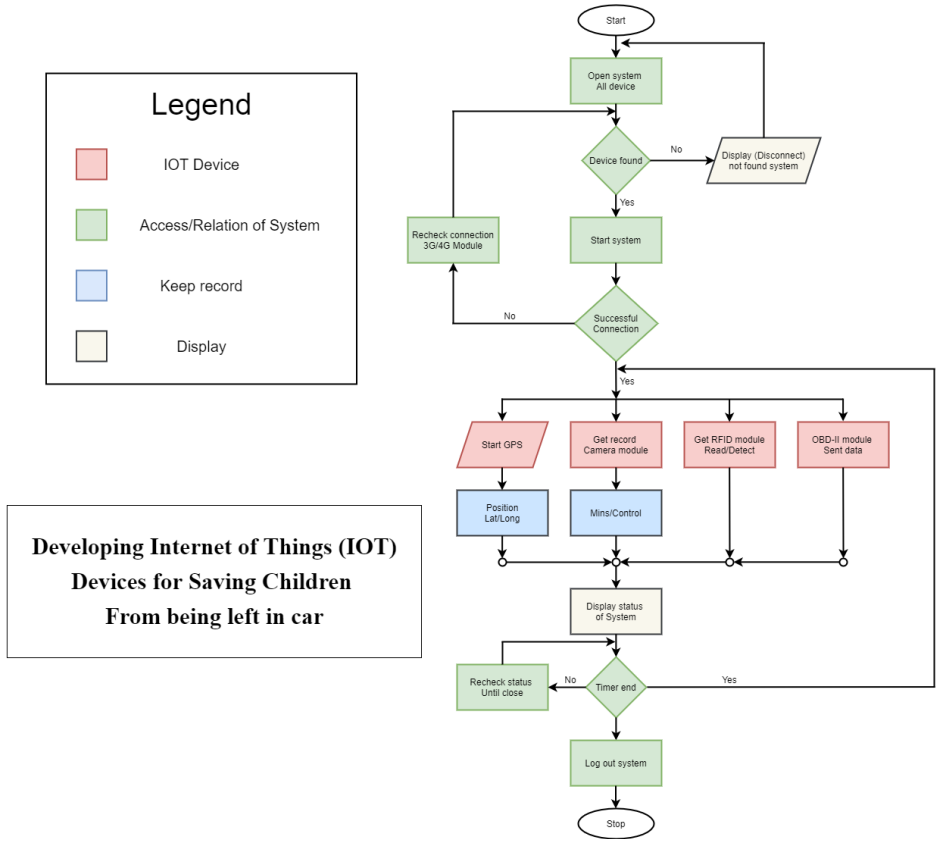


Fig. 5. Flowchart of device.

3.5 Security and privacy

The development of "Developing Internet of Things (IoT) device for saving children from being left in a car", The researchers have concerned that security and privacy are very important to develop mobile application and IoT by the information system. We ensure that cloud server that we choose has a defensive measure to protect data of users. Also prevents computer virus, unauthorized use (hacking) for security and privacy of users [17-20].

3.6 IOT result

For the result of IoT, it can show in type of figure which is shown in Fig. 6 and camera's view are shown in Fig. 7. And GPS module also can track location in real time, but signal is lacked in some signal area. For GSM module, it has received a signal of 3G/LTE only which make a device cannot transmit data to cloud server in some area which has a poor signal.

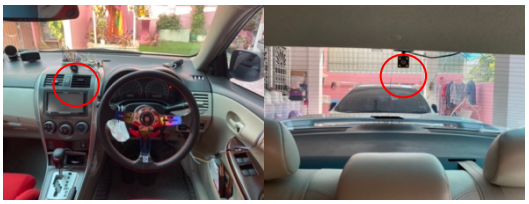


Fig. 6. Position of modules.

Fig. 7. Camera's view.

3.7 Application result

For the result of the application, it can show in the type of authority to access this mobile application which divided into 4 parts, there are administer, driver, teacher, and parents respectively. There are 2 types of home pages for accessing the mobile application: home page of administrator and home page of driver, teacher, and parents as shown in Fig. 8 and Fig. 9.

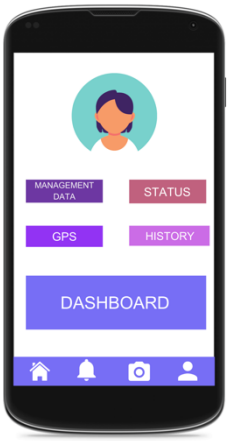


Fig. 8. Home page of administrator.

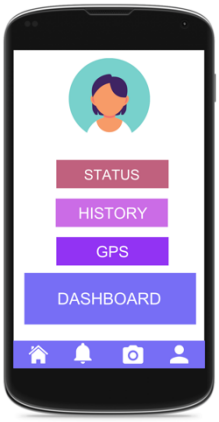


Fig. 9. Home page of dirver, teacher, and parents.

1. Administrator: Able to access all parts of the system, every operation and able to add, delete, edit all various information.
2. Driver: Able to view information in the system and edit car information, personal information.
3. Teacher: Able to view information in the system and edit personal information.
4. Parents: Able to view information in the system and can add, delete, edit their own information, and the information of the students who are parents.

3.8 Analysis result

The analysis result represented in Table 3 shows that attitude in using the application with the satisfaction of the application is level of ($\bar{x}$)=4.20 and when considering each order of the first 3 ranks, we found that the system can be useful to monitor children stuck in the car ($\bar{x}$)=4.53, the system can locate car and children location all time ($\bar{x}$)=4.50, and speed of system output ($\bar{x}$)=4.40 respectively. For the overall system satisfaction score ($\bar{x}$)=4.20. With the lowest satisfaction score, Difficulty in operating the system ($\bar{x}$)=3.73. The result of the research was recorded from 1 Jan 2021 to 31 Jan 2021 and has testers 30 people to test and give some satisfaction assessments of the device system. The gender of the testers from 30 people. Found that male testers are 73.3% and female testers are 26.7%. Also, we used TAM Theory to analyzed the result of the device [14-16].

Table 3. Analysis Result.

	Question	Mean(x)	S.D.	Level
	Usefulness			
1.	The system can be useful to monitor children stuck in the car	4.53	0.56	Most
2.	System can locate car and children location all time	4.50	0.56	Very
3.	System can notify overseers when children stuck in the car immediately	4.30	0.59	Very
	Field of use			
4.	Speed of system output	4.40	0.55	Very
5.	Various functions	4.10	0.47	Very
6.	The system provides accurate results that meet the needs of the users.	4.17	0.52	Very
7.	Difficulty in operating the system	3.73	0.81	Average
	System overview			
8.	Overall system satisfaction with the use.	4.20	0.60	Very

Note* Most (5.00 – 4.51), Very (4.50-4.01), Average (4.00-3.51), Poor (3.50-3.01), Very poor (3.00-2.51).

4. Conclusion

From research, we have a conclude that "Developing Internet of Things (IoT) Device for Saving Children from Being Left in a Car" separated work into two parts which are IoT and mobile application

For IoT, we designed for 3 proposes. There are (1) use RFID module to scan the number of passengers and use RFID tags as an ID card to memory information of ID card's owners. (2) use GPS module to track car and children location in real time. And (3) use 2 camera modules to detect life being in a car when the car is stopped.

For mobile application, we designed for receive data from IoT device and show the result output in smartphone in real time which can use in system of android and IOS both.

From working on both parts, the result is as follow: (1) device can detect life being in the car. And (2) mobile application can notify and see the information from device. Then, we conducted experiments with a sample to collect data and evaluate the result. Therefore, the result turned out to be in good condition. For this research, we created a prototype device to test the system which can attach in all type of car up to users. And in the future, we plan to present this device to every school for safety of the children who use a school bus.

5. Recommendation

At this time, some area that the car passes through are lacked signal. This problem may cause program become error since we used 3G signal to test the system. Reason of using 3G module because it is the most stable equipment, and the price is not too expensive. In the future, if it has a signal receiver module that better than now, it will make the program run at full capacity without any error.

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