

Investigation of Accuracy and Response Time in GPS-based Car Mileage Monitoring Device

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ABSTRACT – Nowadays, newly invented vehicle equipped with smart mileage monitoring system where notification is given when maintenance mileage reached. However, this feature is not own by old car owner. Furthermore, the available monitoring device or system in market is expensive and not accurate. Thus, in this research a Car Mileage Monitoring device with features such as mileage monitoring, maintenance service notification and car tracking system is design and develop. The objectives of this research are to investigate the accuracy percentage of the mileage monitoring system and the response time of the tracking system. In addition, a mobile application is to be fabricated to integrate with the device. In this research, STM32F103C microcontroller (Blue Pill) and A7 GPS+GSM/GPRS module is used. Moreover, Haversine formula is used to calculate distance between two coordinates. The results show that, the average percentage of accuracy for car mileage monitoring system is 91.38%. For response time, the maximum time taken is 24.54 seconds and minimum response time is 13.22 seconds. Furthermore, a mobile application with pop up maintenance notification, car tracking button and mileage reading monitor is developed. In short, the device developed is a reliable device in mileage monitoring where it has a high accuracy percentage when compare to car odometer. Besides, the device is also useful in car tracking where the response time is very short. And lastly, the device fabricated is integrated with a smart maintenance notification where notification is sent when the maintenance limit reach

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1.0 INTRODUCTION

Nowadays, owning a car is not a symbol of luxury life but it become a necessity for those who can afford. In June 2017, a total vehicle number of 28,181,203 units was updated by the Malaysia Automotive Association (MAA) [1]. And according to the data under Global Database's Malaysia, Malaysia's number of motor vehicle at June 2018 was reported at 29,236,492,00 unit which is increased compared to the previous year.

Owner of car seems to forget the routine of maintenance service of their car frequently. To solve this, car with build in car mileage monitoring system. However, old car user still having this problem.

Thus, in this research, a device used to monitor mileage reading, car tracking and maintenance notification is design and fabricate. The usage of mileage monitoring system is to help user to track the reading of mileage through external application such as phone and also notify user for maintenance service. While for the tracking system, it allows user to track the location of their car. It can be used for user who forget where they park their car or as a basic anti-theft device which allow user to track the location of the car from time to time.

To develop the device mentioned, modern technologies that are GPS, GPRS/GSM and microcontroller is used. Besides, a mobile phone application is also developed to integrate with the device. This mobile phone application is used as a platform of monitoring and command centre.

Moreover, to measure the mileage reading there are lots of method had been introduces. One of the method that researcher used, is by calculating the rotation of wheel [2]. However, the reading by using this method will be affected by the radius of wheel and so on. Besides, many researchers claimed that using GPS to calculate the mileage reading is more accurate [3] [4].

Thus, in this research, a device used to monitor mileage reading, car tracking and maintenance notification is design and fabricate. The usage of mileage monitoring system is to help user to track the reading of mileage through external application such as phone and also notify user for maintenance service.

While for the tracking system, it allows user to track the location of their car. It can be used for user who forget where they park their car or as a basic anti-theft device which allow user to track the location of the car from time to time.

The main issues in current existing mileage monitoring system is that most of them has high delay time, not accurate and no additional features such as tracking and maintenance notification. A good system should have lesser delay time. Where delay time will affect the response of the system. While delay time is mostly due to low processing unit and complicated coding. Besides, existing monitoring device in market are expensive and not accurate.

Thus, in this research the performance of the car mileage monitoring system is to be investigate based on the accuracy and the response time of the car tracking system is to be investigate.

2.0 METHODOLOGY

2.1 System Architecture

In the device fabricated, there are two main system flowcharts. The first flowchart is the car mileage monitoring system. As shown in Figure 1, when the device is plugged in or switched on, the GPS and GSM will be initiate. If both systems are function and stable, GPS will take the coordinate of the location. Then the distance travelled will calculated using Haversine formula. Next, the value will send to web server through GSM and lastly, the mobile application read the data from web server.

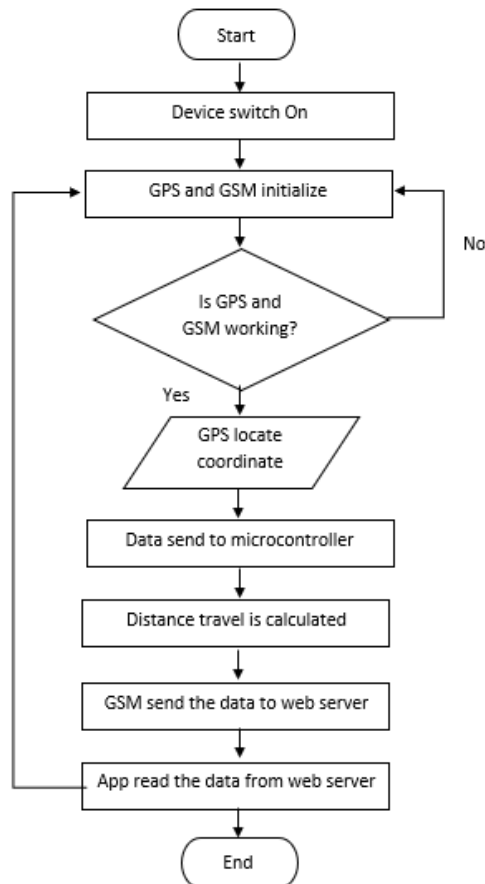


Figure 1: Flowchart of car mileage monitoring system

The second flowchart is the car tracking system. When the device receives a message with word “Track Vehicle”, the tracking system will initiate. Where GPS and GSM will initiate. If both of them are working, the GPS will take the coordinate of the car and GSM will send a message with coordinate details back to user. The tracking system is shown in Figure 2.

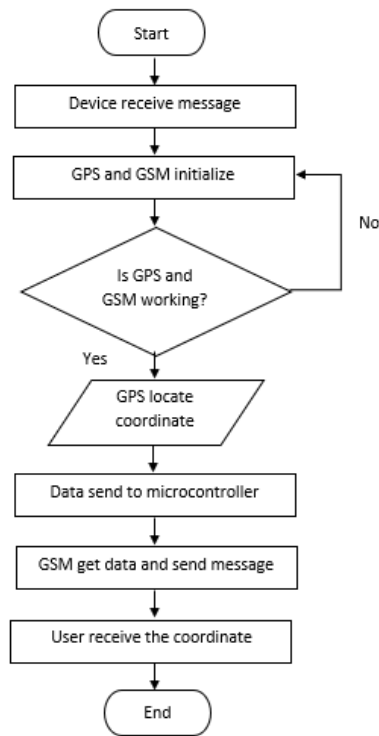


Figure 2: Flowchart of car tracking system

2.2 Hardware Design

In this project, there are mainly 5 main components is used. The first component in the device is the STM32F103C8T6 microcontroller. This microcontroller has high processor which is ARM 32-bit cortex M3 CPU core that can go up to 72 MHz maximum frequency. Besides, this MCU had 64 Kbyte flash memory and 20Kbytes SRAM. Furthermore, this MCU is work like Arduino Uno where it has clock, sleep mode and can be code using Arduino IDE.



Figure 3: STM32F103C8T6 Microcontroller

The second component is the A7 GSM/GPRS+GPS module shield. This is a combination of GPS and GSM module where it reduces the time for the device to response. This module has a maximum 85.6 Kbps download speed and 42.8kbps upload speed. Furthermore, this device support AT-command and Ai-Thinker command. Moreover, this module able to send message, phone call and standard AT and TCP/IP command interface.



Figure 4: A7 GSM/GPRS+GPS Module Shield

The other components are GPS and GSM antenna where use to receive and sending data. And the last component of the device is the USB micro B cable where it is used as the power source and to transferring coding.

2.3 Software Design

In this research, there are three software is used. First software that used is the Arduino Software/ IDE. This software is used to code the coding of the device. By using special library, this software can be used to code the microcontroller used. The second software sued is Android Studio. The used of Android Studio is to design and develop a mobile phone application. And the last software is STM32 Flash Loader. This software is a free software from STMicroelectronics. It is used to load the microcontroller so that it can be work directly using USB port.

2.4 Equation

The data that we obtained from GPS is in latitude and longitude. To calculate the distance between two location. Haversine formula is used. This formula is used to calculate the great-circle distance between two coordinates on a sphere. To use Haversine formula, the latitude and longitude from GPS is first needed to convert into radian form. Eq. (1) showed the Haversine formula.

$$a = \sin^2\left(\frac{\Delta\text{lat}}{2}\right) + \cos \text{lat}1 \times \cos \text{lat}2 \times \sin^2\left(\frac{\Delta\text{lon}}{2}\right)$$

$$c = 2 * \text{atan2}\left(\sqrt{a}, \sqrt{(1 - a)}\right)$$

$$\text{distance} = R \times c \quad (1)$$

From Eq. (1), Δlat is the difference of latitude between two points. While, Δlon is the difference of longitude between two points. And R is the radius of the earth which is 6371km.

3.0 RESULT AND DISCUSSION

In this research, a Car Mileage Monitoring Device is fabricated. The size of the device is 120mm × 80mm × 40mm (length×width×height). This device is small enough to keep and place in the vehicle. There are two faces in this device where one of the faces has two connectors which used to connect with GSM and GPS antenna and the other face is to connect with the micro USB cable. Figure 5 showed the device fabricated.



Figure 5: Car Mileage Monitoring Device

There are few features in Car Mileage Monitoring Device that had been developed. And the main feature is to monitor mileage reading of the car. GPS is used in this study to obtain the mileage reading by calculating the distance travel in kilometres(km) between two coordinates. The results taken are compared with the reading on vehicle odometer to observe the accuracy of the system. The result of accuracy percentage of the Car Mileage Monitoring System is obtained by calculating the percentage of difference of reading taken from the device developed and the reading from vehicle's odometer.

The initial mileage reading of both mediums is set to be the same to obtain more accurate difference. The mileage reading of the device is observed using the mobile application that had been developed. While for the mileage reading and distance travelled of vehicle, the readings are taken from the odometer of vehicle. Furthermore, to ensure that the distance travelled is more accurate or more consistent, travelled path for taking data is set to be the same.

Table 1: Mileage reading and distance travel from Vehicle’s odometer

NO	Vehicle’s Odometer		
	Initial Mileage Reading, (km)	Final Mileage Reading, (km)	Distance Travel, d1, (km)
1	69045	69049	4.30
2	69049	69054	5.00
3	69054	69058	4.30
4	69058	69064	5.90
5	69064	69068	4.30

Table 2: Mileage reading and distance travel from Car Mileage Monitoring System

NO	Car Mileage Monitoring System		
	Initial Mileage Reading, (km)	Final Mileage Reading, (km)	Distance Travel, d2, (km)
1	69045	69049	4.13
2	69049	69054	5.46
3	69054	69058	4.02
4	69058	69063	5.56
5	69064	69067	3.54

Table 3: Accuracy Percentage of Car Mileage Monitoring System

NO	Distance difference, D= d2 – d1 , (km)	Accuracy Percentage, A=100% – (D/d1 × 100), (%)
	1	0.17
2	0.46	90.80
3	0.28	93.49
4	0.34	94.24
5	0.76	82.33

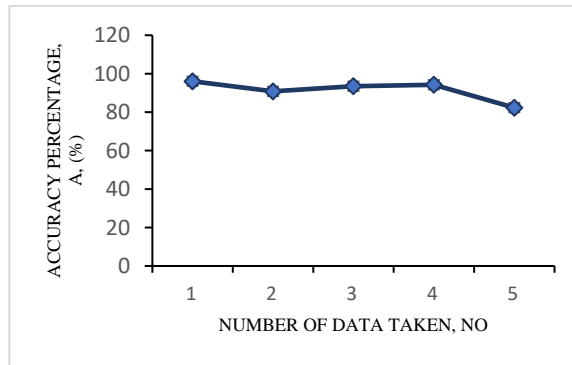


Figure 6: Graph of accuracy percentage

Accuracy is the main issues when discuss about car mileage monitoring system. Thus, accuracy of the car mileage monitoring system is to be investigate in this study. Accuracy of the mileage reading will be affecting the maintenance time and so on, Thus the higher the accuracy percentage, the better the system is. From Figure 6, the range of accuracy percentage is from maximum 96.05% to minimum of 82.23%. While the total average accuracy percentage is 91.38%. From the result, there are difference of 13.72% between maximum and minimum accuracy percentage. Besides that, the difference of distance travelled is not exceeding 1km. The difference of distance is maximum at 760 metres and minimum at 170 metres. The reason of getting difference reading is due to time delay of coding or microcontroller. In this research, microcontroller with ARM 32-bit Cortex M3 is used where the speed of transferring and receiving data is higher when compared to Arduino Uno and Mega. Furthermore, the range of accuracy of GPS is up to ±5metres. The accuracy of GPS will slightly affect the coordinate taken and lastly affected the distance travelled. Another affecting issue is the speed of

car. When the speed (kilometres per hour) of vehicle is very high, the next initial coordinate will be affected. Where there is time delay between previous final coordinate and current initial coordinate.

The second feature of the Car Mileage Monitoring device is car tracking. This feature help user to track the location of the car. Car tracking system work by using mobile phone application that is developed in this research. When user presses the button of “Tracking Car” in the mobile application, it will direct the user to the messaging page of the phone. The message to be send and the number of receivers is all set. What the user needs to do is pressing the send button in messaging page. Next, a message with coordinate of vehicle is send back to user and user can track the vehicle through the coordinate received. In the car tracking system, the parameter that study is the response time. Response time is the time taken for the user to receive the message with coordinate. Or in others word, period of time between sending out tracking message and receiving coordinate message. The response time is measured by using stopwatch. Besides, the data are taken in three different situations. In first situation, the data is taken in 1 km distance between the car and owner. While for the second, the data is taken in distance of 60 km. In the first and second situation, the car is in a stationary state. Lastly, the data is taken while the car is moving. The reasons of taking data at three different situations is to identify whether the distance between the car and owner affecting the response time and is the moving car affecting the response time of the car tacking system.

Table 4: Response time at 1 km distance

NO	Sending Time	Receiving Time	Response Time, T, (Seconds)
1	14.12pm	14.13pm	22.47
2	14.13pm	14.13pm	24.54
3	14.14pm	14.15pm	21.15
4	14.16pm	14.16pm	18.52
5	14.17pm	14.17pm	20.40

Table 5: Response time at 60 km distance

NO	Sending Time	Receiving Time	Response Time, T, (Seconds)
1	10.46pm	10.46pm	15.64
2	10.51pm	10.51pm	15.62
3	10.52pm	10.53pm	17.42
4	10.53pm	10.54pm	18.70
5	10.58pm	10.58pm	13.22

Table 6: Response time at moving vehicle

NO	Sending Time	Receiving Time	Response Time, T, (Seconds)
1	5.34pm	5.34pm	15.42
2	5.38pm	5.38pm	15.24
3	5.39pm	5.39pm	17.10
4	5.40pm	5.41pm	16.31
5	5.41pm	5.41pm	15.84



Figure 6: Graph of response time

A good car tracking system supposed to have a shorter time response. Response time is taken for 3 difference criteria which are distance at 1 km, distance at 60 km and at moving vehicle. From Table 4, the maximum response time at 1 km

distance is 24.54 seconds and minimum response time is 18.52 seconds. While from Table 5, the maximum response time at 60 km distance is 18.70 seconds and minimum response time is 13.22 seconds. And lastly, from Table 6, the maximum response time at moving vehicle is 17.10 seconds and minimum response time is 15.24 seconds. In addition, the average response time for distance at 1 km is 21.42 seconds, 16.12 seconds for distance at 60 km and 15.98 seconds for moving vehicle. From Figure 7, graph line of distance at 1 km is higher to the others while line of distance at 60 km and moving vehicle is almost the same. Moreover, the maximum response time of distance at 60 km is almost the same as the minimum response time of distance at 1 km which is 18.70 and 18.52 respectively. This happened because the mobile network used to take data is different. Where the mobile network use in distance at 1 km is sim Unifi while for distance at 60 km U-mobile is used. However, the overall response time is very fast when compared to the research of other research which have an average of 1.5 minutes to 2 minutes delay in the car tracking system [5]. In short, the response time will not be affected by distance or moving vehicle. It is affected by the strength of mobile network. If the strength of mobile network is poor it will cause a high response time and vice versa.

In addition, in this research a mobile application is developed to integrate with the device. Mobile application that developed is used as the medium the view and read the mileage reading and medium to track vehicle. Besides that, mobile application also works to give notification to user when there is need for maintenance. There are two pages in the mobile application which are Figure 8 and Figure 9.



Figure 8: First page of mobile application

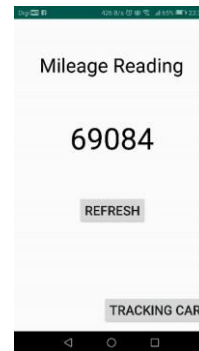


Figure 9: Second page of mobile application

When user opens the mobile application, application will direct to the first page as Figure 8 shown. In the first page user needs to key in the current mileage reading of the vehicle. After key in the reading, user needs to press the “Next” button to go to the second page where at this page the mileage reading is display. After the user travelled, user need to press the “Refresh” button to update the mileage reading. While for the “Tracking Car” button, when the button is press, the mobile application will direct the user to the mobile phone messaging page as shown in Figure 4.10. Then user need to send the message to perform the car tracking system as discuss in previous topic.

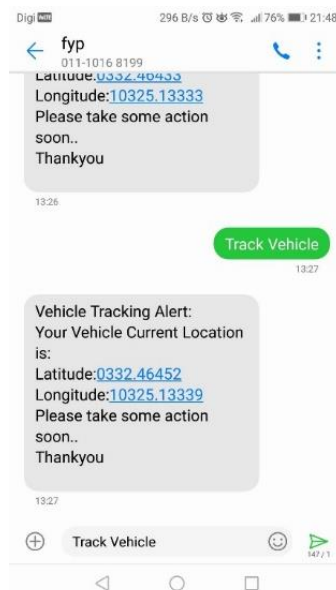


Figure 10: Messaging page of mobile phone

While for the maintenance notification, a notification will be sent when the mileage reading reaches the maintenance limits. A pop up as shown in Figure 11 will occur on the page to notify user. This feature help to remind or notify user to go for maintenance in time where maintenance is very important to vehicle.

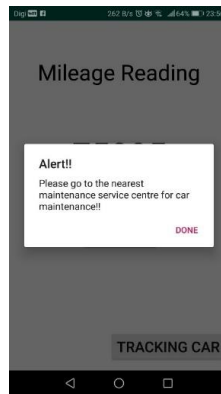


Figure 11: Pop up notification for maintenance

In short, a simple mobile application is developed to integrate with the Car Mileage Monitoring device. This mobile application included the interface to show mileage reading, button to track vehicle and also pop up notification for maintenance.

4.0 CONCLUSION

This paper has presented the results of accuracy percentage of car tracking system and response time of car tracking system. In the investigation of accuracy of Car Mileage Monitoring system, an overall average accuracy percentage of 91.38 % is obtained. This result indicate that the device fabricated is a reliable device to use as a monitoring device. The factors that affecting accuracy is due to the time delaying when locating coordinate. Furthermore, when the car is moving too fast there are few distance is not counted. And the accuracy of GPS will also be affecting the accuracy percentage of mileage monitoring system.

Next, in the investigation of response time of Car Tracking system, a maximum of response time 24.54 seconds is obtained, and minimum response of 13.22 seconds is obtained. While for the average response time, 21.42 seconds is obtained in the distance of 1 km, 16.12 seconds at 60 km and lastly 15.98 seconds in moving vehicle. Thus, the tracking system in this device is also very effective where it has a low response time. In conclude, distance and moving vehicle will not affecting the response time of the system. Car tracking system will be affected by the strength of mobile network. Different mobile network company has different strength. Furthermore, is the area having low connectivity of mobile network it will also affect the response time. The other issue that affecting the response time is the speed of transferring and receiving of microcontroller. In this research a high-speed microcontroller is used to transferring coding to the GPS, thus the response time is lower. Thus, the response time can be reduced is the microcontroller is faster and the mobile network is stronger.

In conclusion, a Car Mileage Monitoring system with the features of mileage monitoring, car tracking, maintenance service notification and integrated mobile application is developed. Besides, the device fabricated is a reliable device to monitor the mileage reading where it has an average accuracy percentage of 91.38% when compare to the car odometer. Furthermore, this device is very useful in car tracking. This device response very fast which has a maximum response time of 24.54 seconds and minimum 13.22 seconds. Moreover, this device also equipped with smart notification system where maintenance notification will be sent when the maintenance limit reach.

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