Mobile Sensors & Solution for Detecting Vehicle Drivers

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***Abstract*—Reduction in road accident still remain a big challenge to current and future transportation system as the rate of road accident rise every year even with all the advancement of technology and initiative by the government.**

With the advancement in technologies and sensor, detection and identification of the user has become a hot topic in research methods. Identification of the user is possible with the support of various research paper but most require a modification to the vehicle which make the method impractical because modification to a vehicle is slow and inefficient. However, some research papers have suggested the method of using the built-in sensors and features that are available on the smartphone. As the world is slowly become technologically advanced, mobile sensors are evolving continually and becoming better and accurate. Hereafter, it will only become more and more advanced and eventually play an important part in our daily life.

Thus, it has motivated us to produce a feasible solution and develop an Android Application called Driver Detection System that only use the sensor to distinguish the user and control and limit the functionalities of the smartphone based on the user to reduce the number of road accident caused by human factor such as the usage of smartphone while driving. Nowadays, modern mobile phones or smartphones are equipped with a variety of sensors such as accelerometer, proximity sensor and gyroscope that are able to capture and record information about users' behaviours. The data can be captured and analysed to model the movement of the user and help in determining the driver. In addition, installing software on a smartphone is notably easier than installing software or modification on a vehicle. Moreover, this paper will describe the background study and related works to the solution and the application.

Keywords— mobile, sensor, vehicle, driver, passenger

I. INTRODUCTION

With the advancement of technologies, road safety still represents a big and significant challenge to current and future transportation system. According to the research conducted by Malaysian Institute of Road Safety Research (MIROS), road user needs to start taking responsibility for the road safety as more than 80% of the road accidents are caused by human error [1]. The rate of road accident keeps increasing every year even with all the technological advancements and the number of initiatives and campaign conduc ted by the government which cause the loss of life and injuries [2]. Road accident is the most unwanted thing to happen to a road user and the number one cause of car accidents is not criminal that ran a red light, drunk driving or speeding The major causes of road accident nowadays are poor driver attitude, fatigue or using mobile phone while driving [3]. Additionally, mobile phones can greatly affect the ability of judgement and divert the attention from driving which become one of the major causes of road accidents.

The problem has provided us the motivation to propose a solution and develop a mobile application, Driver Detection System to determine the user in a vehicle is a driver or passenger and allow the application to detect and control the delivery of information based on the user. Driver can only access to limited functionalities and it will resume after the driver have stopped driving. Upon the completion of the application, road users especially the drivers can have a more focused and better experience of driving, as this application will assist them by limiting most of the functionalities that will affect the consciousness during driving, such as texting, answering phone calls, and gaming. This application will also identify the people inside of a car is a driver or passenger. The system will be installed as an system service application in the smartphone and run as background task all the time. Thus, it can control and disable distracting functionalities of the smartphone if the user is identified as a driver. The application can improve the traffic by lowering the percentage of road accidents happen because the driver is not allowed to use the smartphone and must pay full attention while driving. In addition, installing software on a smartphone is notably easier than installing software or modification on a vehicle. Smartphone apps that track the handling of phones generally monitor app usages and on-screen-time. However, it is not precise enough to detect the usage of the phone while driving and the user may also disable the app or use a workaround to continue using the phone while driving.

As the world is slowly become technologically advanced, mobile sensors are evolving continually and becoming better and accurate. Therefore, we will collect and analyse the smartphone's built in sensor data to model the movement of the user and the phone through various sensors such as accelerometer and gyroscopes which are available in all existing and new smartphones. The captured data can be analysed and help in determining the driver.

II. RELATED WORK

Studies on human behaviour using computational data and identification of the driver in a vehicle is an emerging topic in recent time. The effect of phone usage by the driver have been reviewed and motivated researchers to establish the solution. There are several other researches which use approaches such as using the speakers of the car to play a special sound [7].

Inertial Sensor: For identifying drivers in vehicles, there will have 3 portions in order to detect drivers in a vehicle by one of the methodologies we have read, which are entering a vehicle, sitting at left or right side of the vehicle, and sitting at front or back part of the vehicle. Mobile sensors such as accelerometer, magnetometer, and gyroscope are required in this method, and Earth Frame Coordinate (EFC) values are used as there will be some regular patterns acted by people unconsciously from the perspective of the Earth, while Body Frame Coordinate (BFC) values are not as condition of the motion of smartphones are not consistent, unpredictable, which is hard to analyze [9]. Discrete Cosine Transform (DC-T) is used to extract linear acceleration in order to represent actions collected by mobile sensors in smartphones [8].

When drivers are entering a US based vehicle, location of the smartphone, whether the phone is under left or right pocket of the trousers will give different values when the value is being collected by accelerometer, as shown in Figure 4 provided in the conference paper [9]. High false positive is detected as similar activities such as sitting down on a chair do have similar patterns. Therefore, magnetometer is used to detect changes in magnetic field as magnetic field will vary dramatically compared to approaching a chair, as shown in Figure 5 [9]. Accelerometer will detect a large acceleration when vehicle starts to move compared to sitting still on a chair.

Side detection will be started after entering behaviour has been identified. After a user has entered a car, it will start to analyze which side has the user entered. Based on a US car, a large fluctuation on acceleration followed by a small one will be detected if driver has entered a car at the driver side, and with his/her smartphone under right pocket, and similar result will be detected if passenger has entered the car at another side, with his/her smartphone under left pocket.

In detecting whether user is sitting in the front or the back row, the method which works by calculating distances between smartphone and speakers through acoustic ranging is not being used as it will be based on the placement of speakers in different vehicles. Two approaches are introduced, which are based on the changes in magnetic field when engine starts, and the changes of accelerometer when vehicle passing through bumps and potholes). For the first approach, the level of magnetic field at the back row is larger than at the front row, but there will be a magnetic field vibration which has detected only at the front row, as shown in Figure 7 provided in the conference paper [9]. Another method is to utilize accelerometer and GPS on mobile phones in order to detect bumps and potholes on the road, as they will give significant vertical spikes and dips in accelerations. Back seaters in a vehicle will feel more bump when the vehicle is crossing bumps or potholes, as shown in Figure 8 provided in the conference paper, as the intensity difference between two continuous bumps or potholes at the front row is not large enough compared to that at the back row [9].

For the first method we have found by reading journals and papers, we have found out that the sample data set is not enough. Although they collected sensory data for walking, sitting down, going upstairs and downstairs for 20 cases, and 100 other behaviours, but they monitored and collected all of the sensory data from only one specific user [9]. As different users might do different patterns of motions unconsciously, sample data set should be collected from a number of users in order to improve the accuracy and precision of the data. The usage of vehicle speakers for calculating the distance between smartphones and vehicles is not encouraged in this method, which is one of its strength in order to determine whether the user is at the front or the back seat, as it depends on the placement of the speakers in the vehicles. The use of magnetometer in order to determine front and back seater will be more precise as magnetic field will be stronger, and easier to detect as there will be a fluctuation in the plotted graphs when the vehicle at the moment when the vehicle starts. Mobile sensors such as accelerometer, magnetometer, and gyroscope are also fully utilized, but sensors will have the chance of detecting wrong activities and patterns which are similar to the patterns that might need to have for determining drivers in vehicles.

Mobile Sensor: Another research proposes an event driven solution called Automatic Identification of Driver's Smartphone (AIDS) [10] which uses the common smartphone sensors and then fuzes and analyze the information obtained from the sensors which are related to vehicle-riding activities such as standing near the vehicle, entering the vehicle, etc. Even before leaving the parked position, this system is able to identify the smartphone belonging to the driver with an 83.3-93.3 percent true positive rate while achieving a 90.1-91.2 percent true negative rate. But all of this is done with the drawback of increasing phone battery consumption.

The AIDS system assumes that no significant movements are made by the smartphone when starting the vehicle, vehicles are running on petrol engines and remote vehicle door openers are not available. This system has 5 modules which are categorised into two categories, the system initiators and core system modules. The system initiators consist of Walking and Standing detector (WSD) and Smartphone position classifier (SPC) and as for the core system modules there are Entrance Detector (ETD), Entering Direction Classifier (EDC), and Seated Row Classifier (SRC).

The Walking and Standing Detector (WSD) which aims to detect the walking and standing action of the user. This will detect the when the user stands and activate a subset of sensors to confirm if the user is entering the vehicle or not. Two acceleration features are used to help accurately detect which are the gait cycle and the presence of significant accelerations toward the horizontal plane. When both the features occur together, this indicates that the user is standing while when they are not present indicates that the user is just standing. Several formulas are used to compute the occurrence of both the aforementioned features [10].

The Smartphone Position Classifier (SPC) can differentiate if the phone is in the hands, trousers pocket or in a bag. This information is then used by the ETD to activate the appropriate subset of sensors to acquire a clean set of data about the driver’s smartphone. Then using certain machine learning methods with existing research data [12] the position of the user is classified. The feature vectors that are used for this SPC are the horizontal and vertical acceleration magnitudes and the smartphone orientation [10].

The next module is the Entrance Detector (ETD) which will activate when the user is found standing still for some time. This determines if the user is entering the vehicle or not. Some of the things that the ETD looks for are the variance of EMF fluctuations which should fluctuate when entering a vehicle due to the metal frame of the vehicle. Next would be the positive vertical acceleration magnitude which is caused by the motion of sitting down and lastly would be the closing sound of the vehicle door. But not all of the aforementioned features will be used sometimes due to the phones position.

Following the previous module another core module is the Entrance Direction Classifier (EDC) which activates when the ETD has confirmed that the user has entered the vehicle. It detects if the user has entered the left or right side of the vehicle. The research assumes that the car is American thus the drivers are seated at the left-front of the vehicle. The EDC utilizes the body rotations of the user when entering the vehicle and also the yaw of the phone if the phone is in a bag.

Lastly is the seated row classifier (SRC) which detects if the user is entering the front seat of the back seat of the vehicle. This is done by detecting the subtle fluctuations of the EMF when starting a vehicle. The front seat of the car would yield a higher EMF fluctuation compared to the other rows.

The second method by picking up on common vehicle-riding actions when done with proper fine-tuning algorithms can yield an 80-90% accuracy [10]. But the major drawbacks are that many of the phone's sensors has to be activated and used to produce an accurate result. This would increase the phones battery consumption thus decreasing the phones usage time drastically for some phones

Near-field communication (NFC): Moreover, there are two other possible alternatives such as Near-field communication (NFC) and vehicle speaker system that allow the smartphone to distinguish its user in a vehicle is a driver or passenger. In recent years, latest smartphones and vehicles are equipped with NFC to enable more useful feature such as mobile payment and keyless entry. Therefore, if the NFC system of the vehicle can be modified to notify the smartphone which door is opened by which user, it can determine which user is a driver by checking which user opened the driver door [6].

Although the NFC is a reliable way of detecting the user is a driver or passenger, there are two issues to be discussed here. First, to deploy NFC system, it will require modification to the vehicle itself and the process to modify a vehicle is ineffective and time consuming [6]. Furthermore, the system will only work with modified vehicle and will not work with unmodified car. Secondly, only a small portion of existing and latest vehicle have NFC which make the method not sensible [6]. It is unlikely that this method can be practical since there are so many existing vehicles which does not have NFC.

Audio: In addition, another alternative is to play a special sound with constant sampling frequency that cannot be heard by human ear after the engine starts [7]. The starting time and ranging are recorded and calculated to obtain the result after the special sound is detected. Assuming that the sound has a constant sampling frequency and the speed of sound is known, the physical distance can be computed and the location of the phone in the vehicle is determined by using the result. As a result, we can know which user is the driver by checking the location of the phone in the vehicle.

However, if we want to play special sound when the engine start, the audio file must be stored either in the vehicle or the smartphone. As mentioned previously, modification to the vehicle is impractical and slow because there are so many vehicles on the road. Thus, it is assumed that the Bluetooth connection of the smartphone is already connected with the vehicle Bluetooth system so that the special sound can be played after the engine start [7]. If the connection is not established first or disconnected, the system will fail to identify the user which make it less useful and suitable. Furthermore, the system may not correctly identify the driver in some circumstances even with the access to all the audio channel of the vehicles. For instances, the special sound will become too muffled to be detected if the phone is placed in a bag full of different things or under a thick coat or jacket [7]. Because of this, the system is not secure enough against users who are trying to exploit and cheat the system. Therefore, it is not feasible for enforcement action and the method is impractical.

III. SMARTPHONE SENSORS

There are various types of sensors in the smartphone that are being used in this research.

Accelerometer: Accelerometer is an electromechanical device that is used to measure acceleration force. Acceleration force can be static if the accelerometer is not moving because it will only have a constant gravitational force pulling it. It will become dynamic if the accelerometer is moving or vibrating. It can be used to measure the tilting motion or orientation of a smartphone and sense movement or vibration. For example, an accelerometer is at rest if the acceleration force is 9.81 m/s^2 which is the gravitational force of Earth. An accelerometer is moving or vibrating if the acceleration force is dynamic.

Magnetometer: Magnetometer is an instrument that can measure magnetism or relative change of magnetic field at that particular location. It is widely used to detect magnetic anomalies and used as a metal detector.

Global Positioning System (GPS): GPS is a satellite-based navigation system that can provide the geolocation information to a GPS-enabled receiver anywhere on the Earth if there is no obstruction. It can be used to determine the velocity and determine the position.

IV. METHODOLOGY

Throughout this research, there would be certain real-world variables that would need to be defined. To determine some of these variables we would use the survey method to gather the data. The survey would be distributed to a number of respondents to ask a question on their preference or ideas. The answers then would be compiled and analyzed graphically to determine the answer to the main question.

In addition, Google Form is used for creating questionnaire, as it is a free online survey tool, enabling us to collect their satisfaction towards current road safety. Widespread collection of internet tools such as Google Form can help us to gain more users' feedbacks which will be useful for research in order to have a better and more precise analytical result. Based on the response, we know that most of the road users are not satisfied with current road safety as the rate of road accident keep increasing every year. Furthermore, we have also interviewed some of the road users and drivers, in order to know what limitation of the functionalities should be added to the current system if the user is a driver, in order to ensure that the system meet the user expectation and fit to be released. They also agreed that smartphone use while driving is common among drivers but it is considered as dangerous because it can distract the drivers and cause accidents.

Moreover, existing research and solutions are also a great source of information for this research. We would read and analyze the information we have obtained from external research and solutions to get a better understanding on what has been done and which methods can yield results. Existing research results are important as they are sources of having improvements on the research topics which researchers can extend them in order to get a better, and improved result and contribute more to society.

Except than other analysis methods that are being applied during the researching period, simulations are also important for researching a topic as it gives results and data, and information after analysis which is crucial for the improvement of the research. Simulations for algorithms, methods are important as they can show the performance, time required, and optimizations which we can detect and differentiate which algorithm or method is better overall. Simulations can bring practical feedbacks which will have impacts towards the result for the research. Researchers can use the data obtained from simulations, analyze the data, and get more detailed information and results, which will be helpful and useful for future developments and researches.

Additionally, simulations by using sensors will get humans' behaviors as a result of the simulations, which is practically and technically useful as the changes in readings from all of the sensors such as accelerometer and magnetometer will show that users are getting into vehicles, and driving, which we can classified them as drivers of vehicles, thus setting permissions and limitations on them. During a simulation, a series of activities and movements from users for driving vehicles can be detected by mobile sensors which will return values and data, enables researchers to analyze those values, and determine the definitions and range of values received from those mobile sensors are the one which users will be the drivers. Simulation analysis enables also the calibration of mobile sensors during the research period, as variance of mobile sensors are being installed in different smartphones. As they would have some difference in locating and capturing data values, repeated simulations of events are required in order to take the average and optimum results and calibrate the difference between variety of mobile sensors.

Furthermore, we have created a prototype to implement the research that is being carried out. This prototype would be used to test if a concept works. This method can also find out the real world's problems of the application which cannot be seen or determined during the other analysis. From here we can see which functions are feasible in the real world and which should just remain a concept. We can also get results and values based on the implementation. This can help set thresholds and also improve the accuracy of the range of data.

In the context of this research, the using of mobile sensor to identify driver is chosen in the study because it can yield high accuracy with a fine-tuning algorithm [10]. In addition to that, installing a software to a smartphone is notably easier and cheaper than installing software or modification on a vehicle. Moreover, it doesn't require any modification to existing smartphone because we are only using the data collected from the existing mobile sensor of the smartphone and do not require any modification to the smartphone or vehicle. Thus, the system is ready to be used in existing smartphone and cheaper than any other alternatives that require much effort and time. Although the battery consumption is high because of many sensors have to be activated and used to produce an accurate result, it can be optimised and allow it to operate in an energy-efficient manner. Pre-built existing mobile sensors such as accelerometer, magnetometer and GPS are used in order to accurately detect the position of the users sitting inside of the car, the movement of the car and other factors that constitute to driver-like-behavior in order to automatically detects drivers in vehicles, and limits their use of smartphones, as an effort of preventing road accidents. As more and more people are using smartphones and carry them as their daily drivers, implementing this Android application into smartphones will be ease for them, preventing them from phone distractions and force them to pay full attention while driving. This can help to lower the rate of road accidents.

V. EXPERIMENT AND RESULT

During the experimental phase, various sensor data is retrieved from mobile sensors as only mobile phone sensors are permitted during the process of this research. We have developed an Android app to collect the data of accelerometer, magnetometer and GPS. Data is being retrieved in order to study the act or motion of human beings on various type of actions they will be performed daily. As the 3 most important sensors for detecting human motion are accelerometer, magnetometer and GPS, they can work together in order to detect and help developers to visualize the exact human motions completely after they had done those motions in order to develop features and functionalities for future use. But the problem that is having by those mobile sensors is the irregular and unpredictable change of phone posture in the pocket. As different users might have different preferences in holding or putting their phones into their pockets, patterns of received sensor data might vary from each other, which causes detection of motions will be harder in order to analyze and determine the actual and correct actions and behaviors that users are performing at that moment. Other than that, there will be some data noise in the sensor data collected from various mobile sensors used, as different people might perform different small and hidden patterns regularly, which are different from other people in the world, and will be hard to determine and get rid of.

Vehicle Entry: During this scenario, assumptions such as changes in values of accelerometer and magnetometer, and the position of mobile phones in pockets will be considered, as human motions are included, and materials near users will be changed which causes the increment or decrement in sensor data values. One of the challenging part in this research is to determine the exact timing whether users are going to approach and enter vehicles, or just performing other activities which have similar motions to vehicle entry motions. In this area of the research, activity recognition will be focused.

As the applied application will be activated by the users before approaching the vehicles, all of the mobile sensors will be activated upon the launch of the applied application, and those sensors will be constantly collect sensor data for the analysis process. An experiment for collecting the motion data of accelerometer has been conducted for 100 times in order to get the average data value for fairer experimental result. The average data value from accelerometer is used to set as a baseline in order to test for the cases which varies with the baseline during vehicle entry. We also conducted a set of testing of entering the vehicle with the smartphone in left and right pocket. The test is conducted in a continuous manner: walk toward the car, open the door, enter the vehicle and start the engine. We have discovered similar pattern in the reading of accelerometer when the user is entering the vehicle with the smartphone in his left pocket which can help to detect vehicle entry.

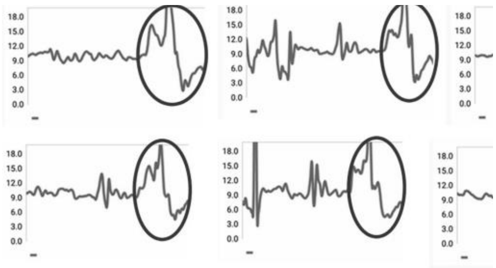

Figure 1: Accelerometer Reading (Smartphone in left pocket)

From the figures above, similar pattern in the reading of accelerometer is seen when the user is entering the vehicle with the smartphone in his left pocket. Repeated attempts have shown this pattern is consistent present when the user is entering the vehicle with the smartphone in his left pocket. The pattern is most likely caused by the first footstep by the left leg in order to enter the vehicle which the driver seat is located on the right side. Although it is possible to enter the vehicle with the right leg first, it is very impractical and awkward to do so and very unlikely to occur. The changes of values detected by the accelerometer can be used for detecting vehicle entry by users. If a similar pattern in the accelerometer is detected, it should mean that the user is entering the vehicle.

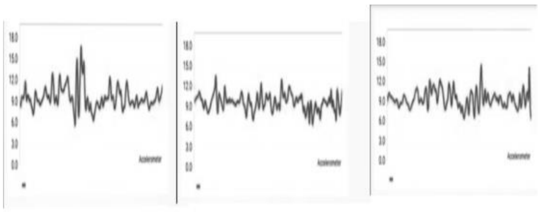

Figure 2: Accelerometer Reading (Smartphone in right pocket)

From the figures above, we can see that there is no consistent spikes at all when entering the vehicle when the smartphone is in the right pocket. This is because the motion of the right leg is not as much when compared to the motion of the left leg when entering the right side of the vehicle. This makes it harder to determine if the user is actually entering the vehicle or just casually moving around when the smartphone is in the right pocket. Sometimes a small spike can be seen when the user drops into the car seat but it will be harder than usual. Therefore, entering the vehicle when the smartphone in left pocket is not included in our research.

The use of external implemented API, which is Activity Recognition API from Google in the research has a purpose of aiding the applied application to ensure that the baseline made according to the average data value of accelerometer during vehicle entry of users is correct and accurate. Various actions such as walking, driving, running and more can be detected by the sophisticated algorithms implemented inside of this Google Activity Recognition API.

Driver Detection: After the successful detection and recognition of vehicle entrances by users of the applied application, driver detection method should be initialized and launched by the application in order to accurately detect the drivers for performing specific actions on them. The use of magnetometer is implemented as magnetic field that surrounds vehicles which are installed with electrical wirings, metals and materials might have a drastic change when specific action is performed. Changes in these components will induce changes in the value of magnetic field collected by the magnetometer in modern mobile phones.

TABLE I. RANGE OF MAGNETOMETER READING

Location		Range of Magnetometer Reading (µT)	
		Before Starting of Engine	After Starting of Engine
Car Park A	Driver Seat	20 – 30	20– 30
	Driver Side Seat	20 – 30	25 – 35
	Passenger Right Seat	30 – 40	10 – 20
	Passenger Left Seat	30 – 40	20 – 30
Car Park B	Driver Seat	70 – 80	70 – 80
	Driver Side Seat	60 – 70	120 – 130
	Passenger Right Seat	20 – 30	30 – 40
	Passenger Left Seat	60 – 70	60 – 70
Car Park C	Driver Seat	40 – 50	35 – 45
	Driver Side Seat	20 – 30	40 – 50
	Passenger Right Seat	30 – 40	25 – 35
	Passenger Left Seat	30 – 40	30 – 40

We have collected the range of magnetometer reading in stationary Perodua Bezza Sedan with different conditions at different location. As it shown in the table above, the magnetometer reading is rather inconsistent and unstable to accurately be used for identifying the driver in the vehicle. This might be due to problems that have found during the period of this research. Based on the literature review done earlier, it has stated there the value of magnetic field will have a significant changes and short spike during the starting of vehicle engines, which is more obvious and significant at the driver side [9]. However, after numerous amount of repeated tests in the vehicles, no spikes are identified and detected, where there is a contradiction with the fact that has been listed in one of the reviewed papers [9].

In addition, we have also discovered cardinal direction will also affect the reading of magnetometer and we have attached the testing video together with this research paper. Evidently a change in direction of vehicles will lead to a change in magnetic field value, for every position in the car, which has caused problems during the analysis process for understanding the trend of magnetic field value changes to detect for drivers' action.

On the Road Detection: Other than vehicle entry detection on users, detection whether users are on the road is one of the vital aspects in this research, as it can predict and show that users are moving according to the available waypoints or roads shown on the map. In order to achieve this, Open Source Routing Machine (OSRM) API is being implemented in the applied application in order to find for the waypoints based on the inputs such as latitude, longitude, radius and bearings provided by the built-in GPS sensors in various modern mobile phones.

We have used a method where we obtain the nearest Waypoints, which are present along the roads, and measure the distance from the waypoint to the coordinate to determine if the coordinate is located on a road. The Waypoints location is obtained from an open-source server named OSRM. In order to get nearest waypoints from a specific GPS coordinate and other information from the open source OSRM server, a HTTP request must be made with a common structure, and a response will be received with each HTTP request sent to the server, with either "Ok" indicates that there is/are waypoint(s) found and the user is on the road based on the inputs provided, or "NoSegment" indicates that the supplied coordinate could not snap to a street segment, which is meant by no waypoints found and the user is not on the road based on the inputs provided. Based on the received response , we can know whether the user is on the road or not. This technique is commonly known as Geocoding.

Some of the difficulties that surfaced are due to the inconsistency of various GPS sensors on different modern mobile devices, will cause slightly misaligned coordinates and eventually causing different results received from the OSRM server. Vendors of GPS sensors are not unified, thus deviations occur when comparing with different types of GPS sensors produced by different vendors.

VI. CONCLUSION

Reduction in road accident still remain a big challenge to current and future transportation system as the rate of road accident rise every year even with all the advancement of technology and initiative by the government [2]. Thus, it has motivated us to produce a feasible solution to reduce the number of road accident caused by human factor such as the usage of smartphone while driving.

With the advancement in technologies and sensor, detection and identification of the user has become a hot topic in research methods. Identification of the user is possible with the support of various research paper but most of them require a modification to the vehicle which make the method impractical because modification to a vehicle is slow and inefficient. However, some research papers have suggested the method of using the built-in sensors and features that are available on the smartphone. Nowadays, modern smartphones or smartphones are equipped with a variety of sensors such as accelerometer, proximity sensor and gyroscope that are able to capture and record information about users' behaviours. The data can be captured and analyzed to model the movement of the user and help in determining the driver. In addition, installing software on a smartphone is notably easier than installing software or modification on a vehicle. Installing applications on mobile devices costs a lot lesser than any modifications on vehicles, yet fully utilized the functionalities that come along with modern smartphones.

In addition, previous research papers are being reviewed and analyzed in order to ensure the trustworthiness of the algorithms and methods being researched. Surveys and interviews will be conducted as well for collecting a quantity of road users' feedbacks towards the factors that constitute to the occurrence of accidents. Analysis will be performed in order to get useful information for showing the performance, efficiency and effectiveness of the methods or algorithms used in order to detect drivers and limit their use of smartphones during drivings. Methods of conducting research are also crucial which they will give constructive results for the successful completion of the research. Several methods are introduced in order to ensure an optimal level of quality of the research is achieved. We have also developed an Android application that is capable of limiting the phone functionalities when the user is in a moving vehicle on the road. This can too avoid the occurrence of road accidents as no one inside of the vehicle can access to any functionalities that can cause the distraction of focus during driving.

In the future, the method can be improved so that it is able to identify the driver accurately without the assistance from external sensors, which has not been done due to the inconsistency of magnetic field values collected by magnetometer. In addition, if the methods is proved to to be practical, it can be implemented in any smartphones as a system application to reduce the rate of accident by prohibiting the user from using the smartphone while driving as it will distract the driver and may cause accidents. It can also improve the traffic by lowering the percentage of road accidents that may occur.

Last but not least, as the world is slowly become technologically advanced, mobile sensors are evolving continually and becoming better and accurate. Hereafter, it will only become more and more advanced and eventually plays an important part in our daily life. There will be more and more innovative ideas such as using smartphone as a virtual key to access your vehicle. Automotive makers are still pressing forward into the future whereby smartphones can be used as a car key despite the security concerns that may present themselves. Tesla, an automotive company that specialises in electric vehicle has already implemented it by using NFC in its latest model, Tesla Model 3 and the technology may be essential in future car because a similar technology is being implemented in Audi A6 [13,14]. Michael Crane, the head of vehicle body and security for the automotive supplier Continental in The United States of America is confident that the smartphone as car key technology will be implemented in most vehicles over the next decades starting with luxury vehicles [13]. This will help us in identifying the vehicle driver because we can know which user is the driver by identifying the smartphone that have unlocked the vehicle and limit the functionalities of it. Hence, users should try and learn all of the modern technologies in order to catch up with the current trend, and getting benefits from those improving technologies.

ACKNOWLEDGMENT

First and Foremost, we would like to express sincere gratitude to our supervisor Dr. Azizul Rahman Mohd Sharrif for providing his invaluable guidance, comments and help. Without his help, we will not be able to get so many valuable and useful information that can help us to continue with our project development.

Secondly, we would like to show our gratitude to Mr. Mohd. Azam Osman, for giving us guidance on the structure of the project that we're developing, the standards and helps during the period of building this application system project. Without him, we will not be able to come out with a proper way to organize, and manage our reports, schedules, which may constitute to a project failure.

Thirdly, as friends are the ones who are following and accompanying us in university, we would like to thank our friends for giving us suggestions, moral supports, and encouragements during the development of the proposed system in order to improve our ideas in the system. We thank all of the people who has helped us directly or indirectly, for finishing our proposed system.

Lastly, we would also like sincere thanks to our parents because they are also an important inspiration and motivation for us.

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