ASM Sc. J., 11, Special Issue 3, 2018 for SANREM, 7-17

An Intelligent Safety Warning and Alert System (I-SWAS) for Automobile Vehicle

Chee, F.P.[1], Angelo, S.F.[1], Asmahani A.[1], Jedol D.[1], Jackson, C.H.W[3]

[1] *Faculty science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia.*

[2] *Preparatory Center for Science and Technology, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia*

An estimated amount of nearly 1.24 million people dies every year from Road Traffic Accident. Despite the fact that most cars nowadays are equipped with automobile safety technology such as seat belts and airbags system, yet, their functionality is only limited for the prevention of further injuries after an accident. Due to the limitations of the existing automobile safety technology, a better and safer automobile design for prevention of pre-accident is therefore crucial. This project introduces a system namely Intelligent Safety Warning And Alert System (I-SWAS) using Arduino microcontroller as a based operation which offers a low cost alternative in automobile safety technology for pre-accident prevention and hence reducing the Road Traffic Accident while providing corrective behavioral elements to the drivers driving ability.

Key words: Car safety, Car safety technology, Road Traffic Accident, Active safety.

I.INTRODUCTION

Road traffic accident is an alarming issue that requires immediate resolution. Based on a statistical analysis by World Health Organization (WHO), nearly 1.24 million people die in road accident each year (WHO, 2013). Demographically speaking, In Malaysia alone 521,446 road crashes were recorded in year 2016 with 7,152 cases were fatal making it rank fifth among the leading cause of deaths in Malaysia (JKJR, 2016)

The fact that most cars nowadays are equipped with basic car safety technology such as seat belts and airbags system, however, the existing safety feature does not attain any accident prevention quality and only works after accident. Due to this limitation, there is a demand for a better and safer car safety system.

Intelligent Safety Warning and Alert System (ISWAS) focuses on the development of a better and safer car safety system that is especially targeted towards existing car users. It offers solution to fatigue driving, obstacle collision and distraction while driving. The system uses sensors and algorithm detection approach which is fully operated on an

*Corresponding author's e-mail: fpchee06@ums.edu.my

affordable microcontroller platform known as Arduino.

A light, sound and touch stimulus is added to this system as a feedback elements that notify the driver when any of the early causes of road traffic accident is detected. Overall, a prototype of new car safety technology was developed.

II. RELATED STUDIES

A. Causes of Road Traffic Accident (RTA)

Human Factor is the most common contributor to road traffic accident. A study by Dequan *et al.,* (2012) stated that occurrence of accidents are usually not due to ignorance but are due to carelessness, too much thinking and over confidence. Another contributing factor to this is the driver physical state such as drowsy driving or distraction while driving which may cause the car to move involuntarily without proper maneuvering and finally due to unintended spontaneous factor such as sudden movement of pedestrian crossing the road (Heinrich, 1941)

Environmental Factor is an unpredictable factor that may contribute to road traffic accident. This factor occurs spontaneously most of the time but can be avoided with necessary precautions. Slippery road conditions during rainy days may cause driver to lose control over their car. Hazy condition may limit the driver's vision hence increasing the probability for obstacle collision to occur. Sudden landslide and flashflood may also reduce the efficiency of road traffic hence contributing to road traffic accident (Badrinarayam *et al.,* 2004).

Mechanical Factor such as the condition of the car engine and tire is another contributor to road traffic accident. Negligence over the cars mechanical wellbeing may reduce the cars overall efficiency hence leading to RTA. Failure in the car system such as flat tire and electronic malfunction reduces the driver handling ability increasing the probability of RTA to occur.

B. Types of Automobile Safety Technology

Generally there are two types of safety technology that are commonly use in the conventional car safety system which are the Passive and Active Safety technology. Passive Safety can be described as a system or device that helps to reduce any further consequences towards the occupants after a crash had occurred (MIROS, 2017). Few examples of passive safety technology are such as safety belts and airbag system. Both of these safety technology will only be triggered after a crash had occurred and remain useless before any crashes. Therefore it can be concluded that the passive safety technology in an automobile system has null efficiency in the prevention of road traffic accident.

Active Safety can be described as system that can analyze the sources of road traffic accident in order to avoid crashes. Few examples of active system are such as the anti-braking system (ABS) and electronic stability control (ESC). Both of these safety technology are triggered before any crashes occur.

C. Conventional Car Safety Technology

Car safety technology is any form of technology equipped to an automobile system in effort to prevent or reduce the effect of road traffic accident. Among the earliest automobile safety technology introduced to domestic automobile user was the safety belt. This section describe some of the existing car safety technology.

Seat Belts is a form of passive safety technology in an automobile safety system that act as a restraint mechanism to avoid the occupants from rapidly moving forward during automobile crashes. Seat belts help to prevent the occupant from crashing onto the wind shield during sudden stop by increasing the stopping distance during an impact (Weis, 2006). The increase in stopping distance increase the time of impact which therefore reduces the overall impulse. The lower the impulse, the lesser the sustained injuries by the driver. Wearing a seat belt reduces the risk of a fatality among front-seat passengers by forty to fifty percent and of rear-seat passengers by between twenty five to seventy five percent (James, 2015).

Airbags is a form of passive safety technology that provides a form of cushion to the automobile occupants during an accident preventing the occupants from hitting hard on the car dashboard or steering wheel. There are few types of airbags such as the front passengers and driver airbags (1), the knee airbag (2), the side airbag (3) and the curtain shield airbag (4). Each of these airbags have their own function but generally they are used to provide cushioning for the occupants during impact. Airbag is usually designed inside a collapsible platform where it can easily be projected towards the driver and passengers in case of accident (Jean *et al.*, 2001). In order for an airbags to be inflated, two triggers must be triggered simultaneously. The first trigger comes from the crash sensor where the arming of this sensor will provide side voltage to the inflator module (Jean *et al.,* 2001). The second trigger is triggered through the actuation of either from the forward motion of the passengers or the passenger discriminating sensor which provide ground to the circuit (Jean *et al.,* 2001). The cushion provided by this airbag helps to reduce extreme impact during crashes which may cause bone fractures. Airbag is very efficient in severe frontal crashes, without associated increase of the severe injury risk at lower speeds with an estimated global severity reduction about 10 percent.

Anti-lock braking system (ABS) is a form of active safety technology. The first mechanical anti-lock braking system (ABS) was designed and produced for the aerospace industry in 1930. The aspiration towards the implementation of ABS in the automobile safety industry was to increase safety (Evans, 1999). The main function of an anti-lock Braking Systems (ABS) is to prevent a vehicle wheels from locking during heavy braking, which allows the driver to maintain steering control as the vehicle rapidly decelerates. ABS functions by detecting the onset of wheel lock-up, due to a high braking force, and then limiting the braking pressure to prevent wheel lock-up. The ECU recognizes the wheel lockup as a sharp increase in wheel deceleration. Braking force is reapplied until the onset of wheel lockup is again detected at which point it again reduces the brake force in a closed loop process. The cyclic application and reduction of braking force ensures that the brakes operate near their most efficient point and maintains steering control. This cyclic application is also responsible for the pulsating that a driver feels through the brake pedal when the system is activated. According to Evan (1999) ABS reduces the risk of crashing into a lead vehicle by 32 percent and increases the risk of being struck behind by 30 percent. Although ABS has good statistic of reducing accident by cars, this system is lacking in the correctness value towards the driver as it did not provide any feedback in form of information.

III. RESEARCH MOTIVATION

This study is targeted towards developing an active car safety system in order to solve the few causes of road traffic accident. Three factors was identified as the primary causes of Road Traffic Accident which are the (1) Drowsy Driving, (2) Obstacles Collision and (3) Distraction while driving. This study present an ingenious solution towards untangling the identified causes of RTA using low cost consumer electronics. The final prototype is targeted to provide an intelligent assistive driving administering semi-autonomous functions with ease of handling. The following section describe the research approach for this study.

IV. RESEARCH APPROACH

A. Fatigue driving detection System

Fatigue driving is a condition when the driver suddenly felt fatigue and sleepy while driving over a period of time. This condition is usually faced by long distance drivers especially during night time. Nearly 20 percent of road crashes are caused by fatigue driving mostly due to the decrease in the driver’s reaction time, awareness as well as judgment ability (Hills, 1980). Previous study have shown various method for drowsy driving detection. According to Sahayadhas *et al.,* (2012) there are three common methods for drowsy detection which are (1) vehicle-based measures, (2) Behavioral and (3) Physiological measures. Each of these method have been effectively used to detect drowsy driving with a certain limitation.

This study showcase a drowsy driving detection method based on Physiological measures using heartbeat monitoring approach. Although there have been a lot of studies using similar approach which emphasize on the monitoring of heart rate for drowsy driving detection, our study proposed a much simpler design in the form of wearable technology.

In this study, we proposed a drowsy detection system based on the driver's heartbeat drop. The fact that an individual heartbeat starts to drop gradually as he felt sleepy can be used as a good indicator to determine drowsy driving. Figure 1 presents the flowchart design of drowsy detection system.

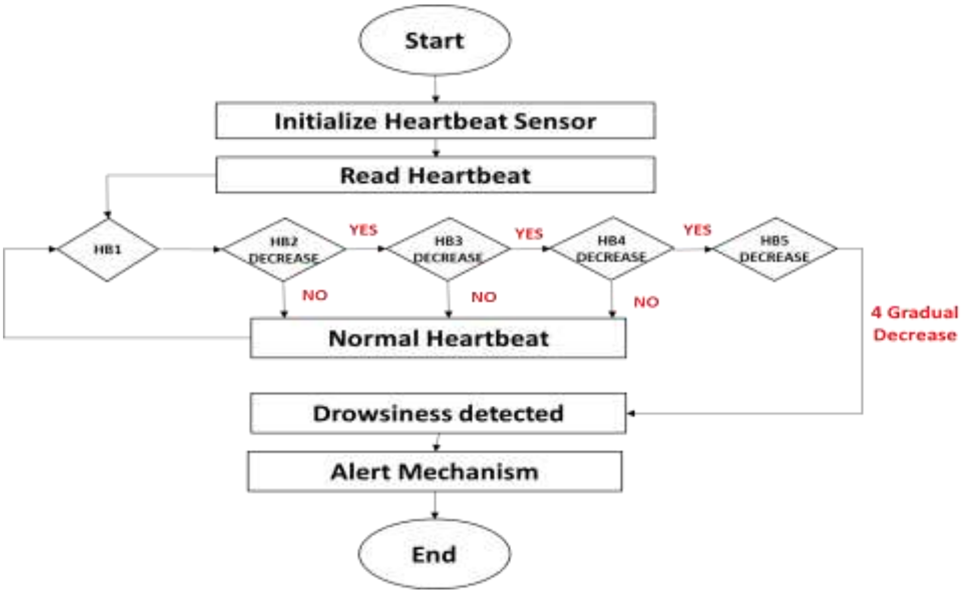

Figure 1: Flowchart Design of Drowsy Detection System

The drowsy detection system works by continuously monitoring the driver's heartbeat over a period of time. If the driver's heartbeat gradually decrease at least in 5 continuous cycle, an interrupt will be activated indicating drowsiness condition is detected. To alert the driver on drowsiness detection is detected, a feedback mechanism in the form of sound and vibrator were integrated into the system. The feedback mechanism will only be activated as alert if drowsy driving is detected. The overall block diagram of the detection system is shown in Figure 2

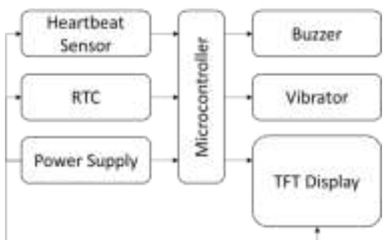

Figure 2: Block Diagram of Drowsy Detection System

To make the detection system more feasible for the user, the overall detection system was integrated in the form of smart watch. The system is added with Thin Film Transistor (TFT) display and real time clock and temperature sensor to make the detection system more practical and user friendly. The completed prototype of the integrated system is as shown in Figure 3.

Figure 3: Integrated drowsy driving detection system

B. Obstacle Avoidance System

Obstacle collision is one of the most common causes of road traffic accident which refers to a condition when the car collides with an obstacles, usually other vehicles, while driving on the road. This in turn led to the driver losing control over their vehicle leading to a more severe injuries and sometimes lethal.

To solve this, the study emphasize on the usage of ultrasonic sensor model HC-SR04 which is capable to detect an obstacles over maximum distance of not more than 400 cm. The ultrasonic sensor is used to detect obstacle around the car when the car is moving on road. The flowchart design of the Obstacle Detection system is as shown in Figure 4.

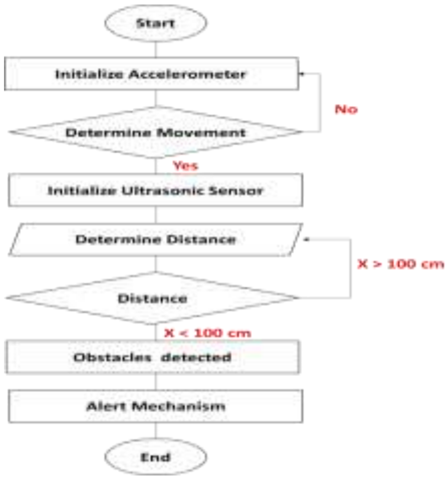

Figure 4: Flowchart design of Obstacle Detection system

The Obstacle Detection system works by firstly determining the movement of car using the accelerometer. This is to avoid the detection system to detect obstacles even at stationary position. Preliminary test shows that the car starts to move, the magnitude of the X, Y and Z axis of the accelerometer will at least read 2G or more. The g-force analysis is presented in Figure 5.

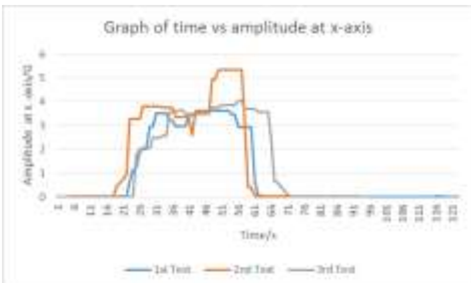

Figure 5: Graph of time against magnitude of force

This data are then used to determine when the system starts to detect obstacles. The obstacles detection system will only be activated if the car starts moving. The obstacles will then be determine by continuously monitoring the distance of the car from any objects surrounding it while the vehicle is still moving. The alert mechanism will be activated if the vehicle detects any objects that are less than 100 cm away from the vehicle.

To provide omnidirectional obstacles detection, four ultrasonic sensor were used in the system where each ultrasonic sensor is positioned in all direction of the car. Sensor 1 is placed facing the rear side, sensor 2 facing the back side and sensor 3 and 4 facing the left and right side of the car respectively. The four ultrasonic sensor detects obstacles simultaneously while the car is moving. The block diagram of the obstacle detection system is as shown in Figure 6.

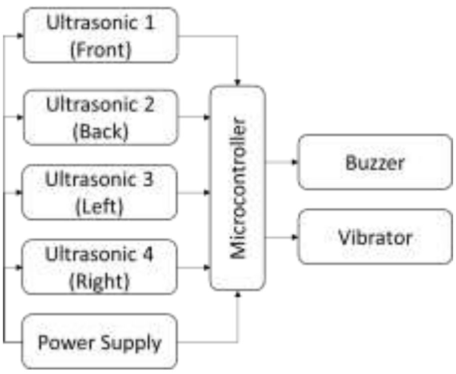

Figure 6: Block diagram for the obstacles detection system

On the completed prototype of the obstacle detection system, the four ultrasonic sensor were placed on top of the vehicle model as shown in Figure 7. The obstacles detection system is able to alert the driver if the vehicle is approaching obstacles less than 100 cm away from the vehicle. The additional accelerometer as initiator is used to avoid the detection system from activating the alert mechanism if the vehicle is at stationary. This design is useful to avoid unnecessary attention especially during traffic jam when the vehicle are bumper-to bumper away.

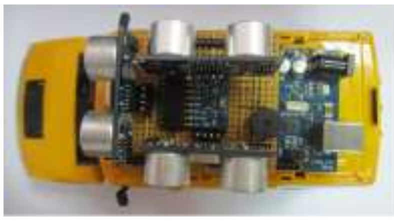

Figure 7: Completed prototype of the Obstacle Detection system

C. Distraction Avoidance System

Another causes of road traffic accident that is starting to become more common nowadays is distraction while driving. One of the major cause of this is the usage of mobile phones by the driver while driving on the road. To address this problem, a smart grip detection system is designed to determine whether the driver is using their phone when driving on the road based on the driver's hand grip on the steering wheel. When, the driver is using their mobile phone, they are unlikely to hold the steering wheel with both hands.

To achieve the grip detection system, a capacitive sensor was constructed using a set of conductive material and resistor. The design of the constructed capacitive sensor is as shown in Figure 8. Conceptually, the capacitance of the constructed capacitive sensor will increase upon contacting with another object. Which can then be used to determine hand grip on the steering wheel.

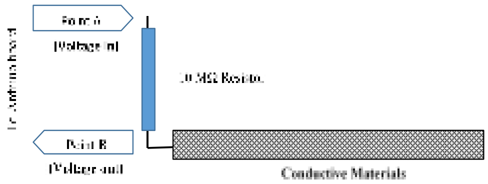

Figure 8: Design of the constructed capacitive sensor

Six sets of capacitive sensor were installed onto a steering cover to maximize surface contact on the cover as shown in Figure 9. Grip test were conducted to determine the changes in the total capacitance of the integrated system when exposed to no grip, single grip and two grips.

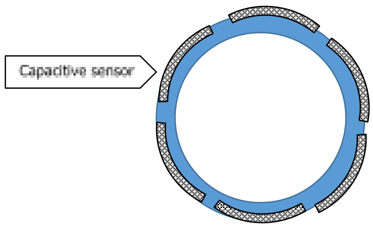

Figure 9: Integration of Six Sets Capacitive Sensor on the Steering Wheel Cover

Based on the results, the total capacitance value differs when exposed to no grip, one grip and two grip as shown in Figure 10. When no grip is applied to the system the total capacitance is less than 5000 farad. When grip with one hand the total capacitance is more than 5000 farad but less than 7000 farad and when grip with both hands the total capacitance reads out more than 7000 farad. This data were then used to construct a grip detection device based on the total capacitance and the flowchart of the grip detection system is as shown in Figure 11.

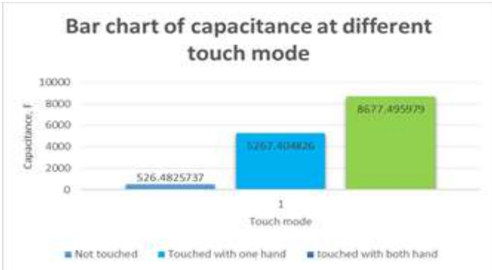

Figure 10: Bar Chart of Changes in capacitance based on touch mode

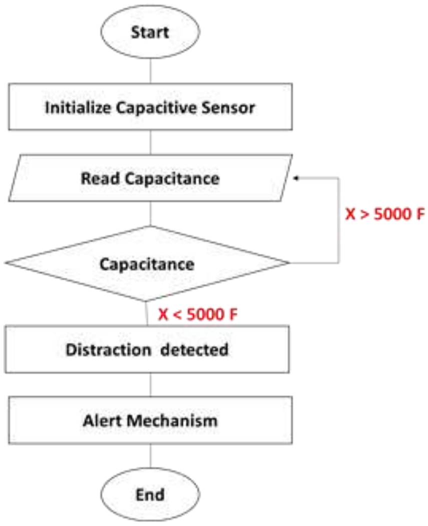

Figure 11: Flowchart of the Grip Detection system

The grip detection system works by continuously monitoring the changes in total capacitance applied on the steering wheel cover. If the total capacitance is less than 5000 farad which indicate that no grip is applied, an interrupt will be activated indicating distraction while driving and the alert mechanism will be activated. The overall, block diagram design of the detection system is as shown in Figure 12 and the completed prototyped is shown in Figure 13.

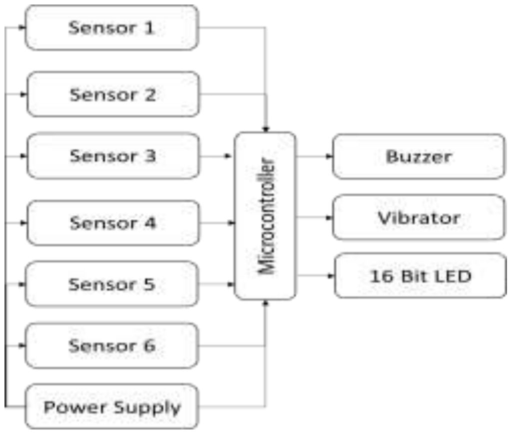

Figure 12: Block diagram of the Grip Detection system

Figure 13: Completed Prototype of the grip detection system

Overall, the grip detection system is able to determine whether the driver is holding the steering wheel with one hand, both hand or not gripping the steering wheel at all while driving. This is directly related to dangerous driving habit. If the driver is not gripping the steering wheel at all, the alert mechanism will be activated in the form of vibration, sound and light stimulus.

V. RESULTS AND FUTURE PLANS

A. Integrations of Detection System

The previous section has describe the approach that has been taken to address each of the identified causes of road traffic accident namely, fatigue driving, obstacle collision and distraction while driving. Each of the designated system can work as an independent system to assist in detection of early sign of road traffic accident and providing alert mechanism for prevention measure. However, in order to increase the efficiency of the system, an integration was made forming an Intelligent Safety warning alert system (I-SWAS) for automobile Vehicle. The flowchart of the integrated system is as shown in Figure 14.

The program is begun by the detection of motion using MPU-6050 accelerometer module. If the module detect any motion from the car, the system will be initiated and the detection of driver's heart pulse, Hand grip, obstacles detection and car motion will start. If any of this detection exceeds the allowable parameters as calibrated. The alert system will be activated and the driver will be alerted. The program will continue to run until the system is turn off. Overall, the integrated system is able to improve the driver car handling thus assist in preventing road traffic accident.

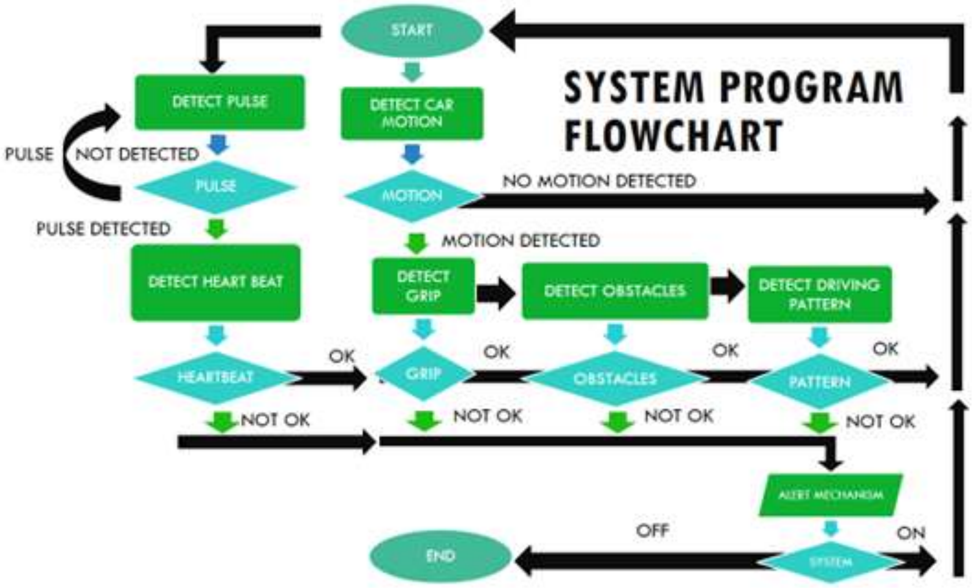

Figure 14: flowchart of the integrated system

B. Future Plans

One of the improvement that can be done for this project is to use visual analysis for the detection of obstacles. Besides that, GPS could also be used to accurately determine the position and motion of the car. An interactive alert mechanism such as alert through social media notification could also be added to further increase the efficiency of the alert mechanism. Finally this study can also be further enhance by applying the designated prototype to a real car to replicate the actual driving situation which were not conducted in this study. By doing so, we will be able to see how well the designated system works in real life situation.

VI. SUMMARY

Rear-end accidents are the most common accident types. The core design of this work is to provide a collision warning in situations when the driver is in dangerous driving habit or when the vehicle is approaching a preceding obstacle or vehicles with a high closing rate. The completed prototype is tested at several conditions and it was proven useful to avoid severe car accident due to fatigue driving, obstacle collision and distraction while driving. The strength of this design is the ability to provide a visual, tactile and audible warning when the probability of crash exist.

[1] World Health Organization (2013). *Global Status Report on Road Safety 2013*. Luxembourg: World Heath Organization

[2] Bahagian Dasar dan Inovasi (2016) *Buku Statistik Kemalangan Jalan Raya*. Kuala Lumpur: Jabatan Keselamatan Jalan Raya (JKJR) Malaysia.

[3] Dequan, G., Xiangzhen, L. Chengyue, Y. & Yiying, Z. (2012). *Spatial patterns analysis of urban road traffic accidents based on GIS. International Conference on Automatic Control and Artificial Intelligence (ACAI 2012)*. (pp. 1898-1901). Xiamen, China: IET.

[4] Heinrich H. W. (1941). *Industrial Accident Prevention A Scientific Approach*. New York: McGraw Hill

[5] Badrinarayan, M., Nidhi D. S., Sukhla, S. K., Sinha, A. K. (2004). Epidemiological Study Of Road Traffic Accident Cases: A Study From South India. *Indian Journal of Community Medicine*. 29(1), 20-24.

[6] Ahmad Noor Syukri Z. A., Siti Atiqah M. F., Fauziana L., & Abdul Rahmat A. M. (2012). *MIROS Crash Investigation and Reconstruction Annual Statistical Report 2007–2011*. Kuala Lumpur: Malaysian Institute of Road Safety Research

[7] Weiss, H. (2006). International survey of seat belt use exemptions. Injury Prevention, 12(4), 258-261. doi:10.1136/ip.2005.010686

[8] James, D., H. (2015). *Automotive Electricity and Electronics*. Ohio, United State: Pearson Education Inc. (pp. 20-23.)

[9] Jean, F. H., Yves, F., B., Gérard, F. & Jean-Yves, L., C. (2001). *Airbag Efficiency In Frontal Real World Accidents*. France: SAE international (Pp. 24 28)

[10] Evans, L. (1999). Antilock Brake Systems and Risk of Different Types of Crashes in Traffic. Journal of Crash Prevention and Injury Control, 1(1), 5-23. doi:10.1080/10286589908915737

[11] Hills, B. L. (1980). Vision, Visibility, and Perception in Driving. Perception, 9(2), 183-216. doi:10.1068/p090183

[12] Sahayadhas, A., Sundaraj, K., & Murugappan, M. (2012). Detecting Driver Drowsiness Based on Sensors: A Review. *Sensors,12*(12), 16937-16953. doi:10.3390/s121216937