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# Life Case: Inelastic Collision based Automobile Crash Detection and Alert System via 3G Network

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***Abstract* - Accident detection and alert systems that can pinpoint the whereabouts of an accident are crucial to ensure the concerned authorities are informed instantaneously about the occurrence of an accident, in order for the deployment of emergency response to save lives in the least amount of time. A 3G incorporated accident detection system, known as Life Case is designed to discover the accidents between automobiles and, send the timestamp, and the actual position of an accident, to a developed android application built using Android Studio, via a cloud database. The alert message is presented using Google Maps which helps user to save plenty of time through easy navigation feature towards the accident location. Life Case measures the acceleration of an automobile during a collision using the Theory of Inelastic Collision.**

***Keywords—Inelastic collision, 3G connectivity, IoT, Raspberry Pi, Android application***

## I. Introduction

Traffic accidents in Malaysia are one of the major causes of fatalities, which is due to numerous factors such as inadequate street lighting, unsafe road conditions, faulty traffic lights and high speeds of vehicles. Major types of car accidents encompass vehicle rollover, rear-end collision and head-on collision that causes high rates of death tolls. The government of Malaysia established road safety strategies such as initiating the Malaysian Institute of Road Safety Research (MIROS), introducing road safety education in schools and enforcing the road transportation law have been administered by the government of Malaysia to resolve this issue [1].

Victims of automobile accidents could not be saved on time because the concerned authorities such as family members, police authority and medical assistance are not alerted of the occurrence and whereabouts of an accident. The authorities would only know about the incident if nearby people happen to come across the accident, which creates a huge delay in the arrival of medical assistance to the accident spot. Victims may die because they could not be saved on time. There are many accident detection systems developed using various techniques in the past, but most of them rely entirely on Wi-Fi, which has limited network coverage, to notify the situation to the people. Public hotspots in cities offer Wi-Fi service, with the placement of Access Points (AP), which only cover a limited range of areas [2].

Sherif *et al.* [3] discusses an accident detection system in which, various sensors were integrated to form a Wireless Sensor Network (WSN) with Radio Frequency Identification (RFID) tags. The system will detect movements and vibrations of a car and sends an alert message to a monitoring station during a collision.

Another similar type of work was presented by Sharma *et al.* [4]. A smartphone application was developed that collects the data from a 3-axis accelerometer and removes unwanted noise to extract the actual fluctuations in acceleration of a vehicle. An accident will result in the deployment of in-built vehicle airbag and transmission of predefined message to emergency contacts via SMS.

Kavya *et al.* [5] proposes an accident detection system developed using accelerometer, GPS module, GSM module, and Raspberry Pi in paper [5]. The system senses any abnormal physical changes of the vehicle like tilt, rollover, and extreme vibrations. During accidents, the connected



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GPS module extracts the location of the accident spot, which will be immediately sent to an emergency number through a GSM module and cloud storage.

Surakul *et al.* [6] presents a system in which Arduino Uno Microcontroller, Inertial Measurement Unit (IMU), GPS module and the 3G cellular module were integrated, that utilizes the advantage of collected data from accelerometer, gyroscope, and magnetometer, which construct IMU, predicts the upcoming motion of a vehicle. Generally, collected data from the sensors are used to calculate the change in angle of a vehicle route and distance between the current position of a vehicle and following position that the vehicle moves to, in terms of the x-axis and y-axis.

The research done by Jain *et al.* [7] presents a system that uses Raspberry Pi as the main server, along with a GPS module to detect the longitude and latitude of the accident spot were designed. The system also utilizes two additional devices such as pressure sensors and Pi camera to ascertain the causes of accidents. The pressure sensor is connected to the raspberry pi which, in the case of accidents, detects the jerk of a vehicle, where the Pi camera located in the dashboard of the car captures an image of the driver when a certain level of vibration is obtained. During a collision, the extracted information is sent to an android application that displays vehicle number along with the latitude and longitude of the accident spot to the family members through smartphone.

Shabbeer *et al.* [8] proposes a system comprises 6-axis accelerometer, GPS module, GSM module, and Arduino microcontroller, which is attached to a helmet to identify traffic accidents among motorcycles. In the system, an accelerometer is integrated with gyroscope, which determines the values of acceleration in the x-axis, y-axis and z-axis and angle of the motorcycle during motion. During accidents, GPS module that is present in the system, retrieves latitude and longitude of an accident location, which will be sent along with vehicle type and vehicle identification to an internet application. This followed by the generation and transmission of email to the preferred contacts. Later, the stored coordinates in the database are retrieved and used to display the actual geographical location of an accident to the user through the Google Maps.

## II. METHODOLOGY

### *A. System Design and Configuration*

In this paper, a system will be designed using Raspberry Pi B, GPS Module and Accelerometer with 3G incorporation for extended coverage. The system extracts the location of an accident spot and, time and date on which it occurred. The acquired information will be presented using a developed android application.

The integration of Raspberry Pi, Android Application and Cloud Database with by the means of Internet of Things (IoT). IoT facilitates daily routines with less utilization of time and effective usage of resources. Network of IoT sensors and devices allow information to be delivered more efficiently, which increases productivity in applications such as security, connected-cars, and business [9]. Raspberry Pi is a small-sized device that works like a computer. It is portable and enables communications with other devices for building embedded systems. The usage of smartphones is quite common among people or could be the norm. It is small and can be easily carried away in pockets. The demand for smartphones is getting higher day by day, as they make humans life way easier by keeping users updated them with the latest information using development of android application [10]. A database enables users to store customer profiles, IOT data and product details in it, which can be read anytime [11]. A cloud database can be described as, a medium that runs on a cloud computing platform, which holds significant data, that can be extracted anywhere with a simple internet connection. Combination of these three technology with some improvements can overcome the limitations of past works.

Transmission of information via RF technology in [3] that leads to data loss due to interference of other signals such as GPS signal and mobile signals will be rectified with the usage of a cloud database to store the collision information for secured date throughout the event. In paper [4], the utilization of SMS service can be replaced with an android application that will be designed to serve a particular application like a collision detection system. An android application that is meant for a specific purpose will not be a place for junk messages and spams. Moreover, a collision detection system [5] will be created that will operate on Wi-Fi as well as 3G service. Since 3G network coverage is broader compared to Wi-Fi, the system can work everywhere without interruptions. An android application will be designed with pop-up notifications and pop-up sounds to capture as much of the people's attention as possible. This can overcome the drawback in paper [6], where the system can only detect accidents but will not alert the authorities. Disadvantage in paper [7], will be rectified, as the proposed android application enables the user to view the exact geographical position of an accident spot using Google Maps API. The API connects the android application to Google MAPS automatically, which reduces delay as the user does not have to waste time to key in longitude and latitude manually in Google Maps. Finally, the user will only need to take a glance at the proposed application, if there is any notification. Lastly, the user does not need to keep checking the application on a repeated cycle. People will feel more comfortable using this application, as it does not waste their time, resulting in the acquirement of huge attention from many people to a collision, which will overcome the limitation in the paper [8].

### *B. Block Chart*

In-vehicle vibrations in automobiles occur mainly due to the operation of the engine and other factors such as road conditions that vary pressure to the tires, slowdown of vehicle and movements over speed bumps. The proposed system will be designed to study the produced level of vibrations in correspondence with the behaviour of a vehicle. These generated vibrations will be measured and analysed in terms of acceleration, $m/s^2$ where fluctuations in the levels of vibrations will be considered as acceleration and deceleration of an automobile. Figure 1 represents a block diagram of the proposed system that consists of a Power Module, Impact Module, Control Module, Network Module, and Report Module.

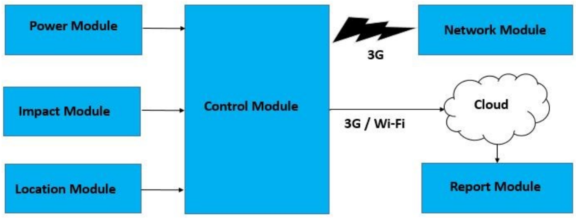


Fig. 1. Block chart of life case.

*C. System Architecture*

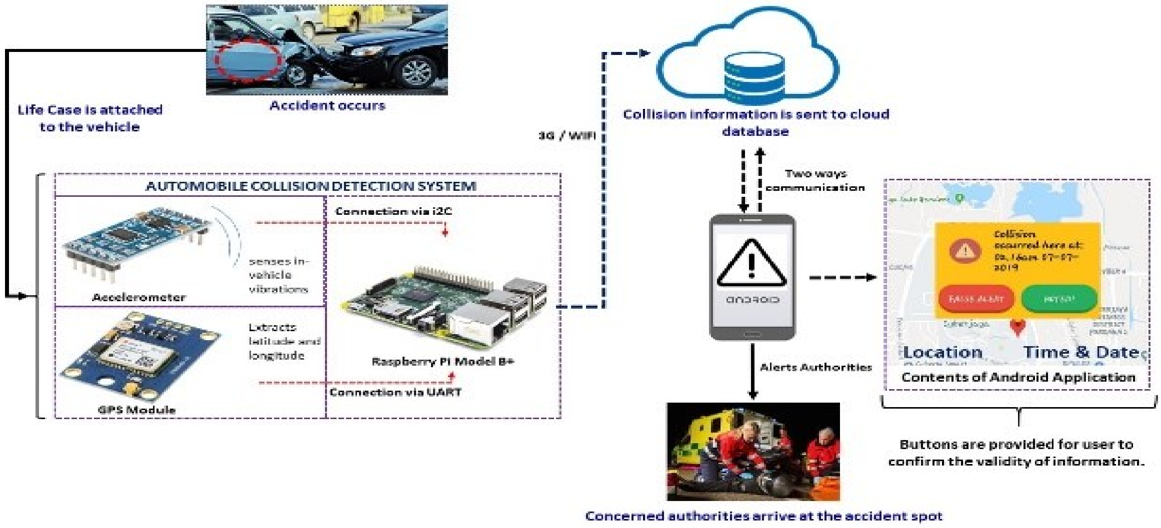


Fig. 2. System architecture of life case.

Life Case detects traffic collisions and discovers the right location of an accident spot. The obtained information will be sent to a cloud database via third-generation (3G) or Wi-Fi networks for extended network coverage, which enables the system to be in continuous operation. The information is sent to an android application via a cloud database. The retrieval of the data in the application is brought to the attention of a user, by pop-up notifications and sounds. Lastly, the retrieved information is presented using the Google Maps, which lets the user view the actual geographical position of an accident spot and navigate towards the location in the least amount of time. Figure 1 shows the system architecture of Life Case.

*D. Collision Detection*

In this design, a relationship was created between vibration and acceleration, which was confirmed later that vibration is definitely interrelated with acceleration. Observation of vibration in the acceleration perspective enables the usage of the principles of inelastic collision in physics. In the real-world, every collision is inelastic even though the affected vehicles rebound, where kinetic energy is always lost due to internal friction. Inelastic collision in a traffic accident occurs when two vehicles hit and stick together after an accident, in which the initial momentum of the vehicles before the collision is equivalent to the final momentum of the vehicles together after the collision. Equation of momentum comprises initial momentum ($Po$), final momentum ($Pf$), mass of first vehicle ($m$), mass of second vehicle ($M$), initial velocity of first vehicle before collision ($vo$), initial velocity of second vehicle before collision ($Vo$), final velocity of both vehicles together after collision ($Vf$). Formula of momentum is as shown below: -

$$P_o = P_f \tag{1}$$

$$mvo + MVo = (m + M)Vf \tag{2}$$

Weight of involved vehicles and, initial velocity in which the vehicles travelled are always known. Based on these details, the final velocity of the vehicles after the collision can be calculated using the equations shown above. For an instance, if a car that is moving east collides with a truck moving west, it will become stuck on the hood of the truck and both of them will move west or the same direction after the collision. It is assumed that the final velocity of the car becomes zero at the moment of the collision, whereas the truck still moves but probably at a slower velocity than before. Obtained final velocity, $Vf$ can be used to determine the acceleration and deceleration of the affected vehicles using an equation that takes the difference between the final velocity and the initial velocity, $Vi$, and has an additional specification, which is the time taken for a vehicle to alter from initial velocity to final velocity, $t$. The equation is shown below: -

$$Acceleration, m/s^2 = \frac{Vf - Vi}{t} \tag{3}$$

A study was conducted based on Inelastic Collision. An analysis was carried out, in which a few types of vehicles were selected, of which will be considered as model vehicles that will collide with an automobile, Nissan Sentra facelift 2008 SG 1.6. The deceleration values the automobile provides during collisions with the other vehicles will be calculated using Eq. (1), Eq. (2) and Eq. (3). During a collision, it is assumed that the amount of vibration experienced by the car varies according to the type of vehicles it collides with. Besides, the total time taken for a collision to occur and the velocity in which the vehicles travel is assumed as 0.2 s and 70 km/h respectively. Both cars travel at the same speed, which is 70 km/h, heading toward each other. However, the reason behind the representation of velocity of Perodua Myvi with negative sign is that the car moves from the opposite direction. In fact, based on the theory of inelastic motion, either one car of which velocity must be stated with a negative sign. The negative sign is to denote the opposite direction, which will be considered in the calculation to determine the acceleration. Deceleration values of the midsized car during the collision with the all other vehicles are calculated using the equation of momentum which shown in Table I.

Table I. Weight of various types of vehicles.

| Types of Vehicles | Vehicles | Weight, kg | Velocity, km/h |
|---|---|---|---|
| Compact | Perodua Myvi | 1120 | 70 |
| Midsized | Nissan Sentra | 1420 | 70 |
| Large | Proton Exora | 1636 | 70 |
| Truck | Hino Ranger | 6914 | 70 |
| Bus | Volvo B8RLE | 19000 | 70 |

In Table I, midsized car moves east while the others move west and collide with the car. Subsequently, in Table II, deceleration of Nissan Sentra of collision with Perodua Myvi is calculated as −85.739 $m/s^2$. The system is instructed to alert the concerned authorities once the accelerometer provides acceleration of less than the specified value.

Table II. Deceleration of Nissan Sentra after collision.

| Vehicles | Deceleration after collision , $m/s^2$ |
|---|---|
| Perodua Myvi | −85.739 |
| Nissan Sentra | −97.222 |
| Proton Exora | −103.797 |
| Hino Ranger | −161.3125 |
| Volvo B8RLE | −180.9225 |

*E. Impact Module*

Impact Module is comprised of an ADXL 345 accelerometer, which determines the acceleration of the system. The sensor communicates with the system using the I2C serial bus. It is a digital accelerometer that works as similar to any other Microelectromechanical systems (MEMS) accelerometers where the fluctuations in capacitance values in the sensor are converted to voltage proportional to acceleration at each axis [12]. In this design, the ±16 g scale with a resolution of 10 bit is selected. Initially, the output of the accelerometer is in voltage or known as raw data in the unit of LSB/g. The voltage values are divided by sensitivity or LSB/g factor of every axis, which is provided in the datasheet of ADXL 345. Chosen ±16 g scale represents a g-range of −16 g to +16 g, where the upper limit is the largest g-value that the accelerometer can measure up to. The range sums up to a total of 32, which is the sensitivity of the chosen range. On the other hand, resolution of 10 bits can be represented as 1024 in decimal format, where 1024 different readings can be obtained for the selected g-range. Based on this information, the g-value of which the readings from the accelerometer changes by, is calculated using Eq. (4).

$$\frac{Sensitivity}{Resolution} = \frac{32\,LSB/g}{1024} = 0.03125 \qquad (4)$$

In this case, each time the output voltage of the accelerometer varies by LSB/g, the g-value differs by 0.03125 g. An analog to digital converter in the inner side of ADXL 345, transforms the voltages to digital values based on the g-range and resolution that is chosen. The output raw values of X-axis and Y-axis are converted to g-forces by dividing them with the sensitivity. Lastly, the g-value will be converted to acceleration, by multiplying it with the acceleration of gravity, where 1 g is equivalent to 9.60665 $m/s^2$.

*F. Location Module*

The location module consists of the GY-NEO6MV2 Flight Control GPS Module, which is responsible for extracting the actual geographical position of a location in terms of longitude and latitude. It is a small chip that contains an in-built voltage regulator, which operates within 3.3 V and 5 V. The module is quite cheap compared to most of the GPS modules in the market, plus it is designed to have Time-To-First-Fix (TTFF) of less than one second. The lower the TTFF, the faster the module can procure satellite signals [13]. The type of output that the module provides is in compliance with the National Marine Electronics Association (NMEA) standard, which is not user-friendly. It is a standard information format adhered by every GPS designer, that enables computer users to integrate software and hardware. NMEA output generally contains longitude, latitude and additional GPS information of a location. The latitude and longitude in the breakdown NMEA message above, are in degrees, minutes and seconds format (DDMM.MMMMM), which cannot be simply extracted. Since, Google Maps API used in the design supports decimal degrees' format (DDD.DDDDDD) only. Hence, the data must be extracted and also be converted to decimal degrees' format, by retaining the DD segment and simply divide the MM. MMMMM segment by 60. Finally, both will be summed up to obtain the final coordinates. This method will be carried out on latitude as well as longitude. This module communicates with the Control Module using a serial communication protocol known as Universal Asynchronous Receiver-Transmitter (UART).

*G. Control Module*

Control Module acts as the main server of the system, which is made up of Raspberry Pi Model B. The single-board computer, consists of Universal Asynchronous Receiver Transmitter (UART), Serial Peripheral Interface (SPI) and I2C serial communication ports, plus a few GPIO pins [14]. Impact Module and Location Module are connected to SPI and I2C serial ports of Raspberry Pi respectively for data sharing. The created program is divided into three major sections, which are collision detection with Impact Module, extraction of longitude and latitude of accident spot using Location Module and, the transmission and retrieval of accident information using a cloud database. The cloud database will be partitioned into two sections, where the first one would be the transmission and retrieval of text box using the cloud, whereas the second part is dedicated to a communication path between Control Module and Android application, Mobile Token. Besides, the system consists of a text box, divided into five categories known as Collision Status, Notification Status, Latitude, Longitude and time stamp, which construct the first part of the database. Moreover, the combination of these sections integrates the behaviour of the modules and cloud database to notify the concerned authorities about an accident. If the acceleration values exceed a restricted acceleration range indicating an accident, the impact module triggers the Location Module to search for the latitude and longitude of the current geographical position. Later, the previous processes are followed by the search of current time and date. The obtained data are saved in a text box according to their respective categories and at the same time, a mobile id is generated containing Notification Status and timestamp, which will be sent to an android application. Finally, the text box is sent to the cloud database.

### *H. Cloud Database*

The cloud database known as Firebase Real-Time Database by Google was utilized in the project. The cloud database does not require much programming in SQL language as other databases do. It is a cloud-hosted database that can be simply utilized to synchronize data across a network of clients in real-time and supports cross-platform applications like Android, as users share one database to receive real-time notifications with the latest data [15]. As long as a device is connected to an internet connection, the user can receive updates from the cloud database. This enables the notifications to reach at least one connected client, in the case of an accident. Connection to the cloud database is initiated with the help of Firebase Application Protocol Interface (API) allows the usage of a few simple commands for that purpose. A main class called, "Alert Event" is formed. The class has two sub-classes, which are geolocation and status. Later, another class named Mobile Token, was created which is dedicated for the connection between Control Module and Report Module. The mobile token contains the unique ID of the connected smartphone along with the notification status and timestamp. These data will be popped up at the smartphone screen during a collision. Generally, Firebase Cloud Service for Android generates a unique ID for every smartphone that is connected to the database. Only when the unique id of a smartphone is known, the information could be sent to the Report Module.

### *I. Report Module*

The android application will show the exact location of the accident spot, date, time of collision, notification status which utilizes Google Maps API, to present the actual geographical position of the accident spot to the user with auto-navigation feature for the user to navigate towards the accident spot. The application makes use of the availability of marker provided in Google Maps API, to pinpoint the exact location on the map. The android application is designed using Android Studio, which is connected to the cloud database. It is designed in such a way, where it checks for data presence, text box in the database. The connection was done with the usage of a few API's for Android offered by the Firebase Service. The application is designed with two buttons such as False Alert and Noted, which allow a user to confirm the occurrence of a vehicle accident. User is advised to press the False Alert button, if the notification is false, whereas the Noted button must only be pressed if the user thinks that the information is valid. The activation of these buttons prints a message at the bottom of smartphone screen, to inform other clients connected to the database, about the validity of the collision notification. On the other hand, usage of these buttons will update the Collision Status in the text box. False Alert and Noted buttons will update the Collision Status to "Ignore" and "Checked", respectively. Data is retrieved from the database and presented with a pop-up window. The pop-up window contains the two buttons and designed with a sharp edge that points the location of an accident.

### *J. 3G Module*

The 3G Module is made of TP-Link 3G HSPA+ Mobile Broadband Wi-Fi Router 21.6Mbps (M5350), which supports 3G broadband connection. 3G is viewed as the third generation of wireless mobile telecommunications service, with several enhancements compared to previous wireless technologies, like 1G and 2G [16]. The module generally establishes a 3G hotspot and shares the wireless internet connection to any device that supports Wi-Fi connection. The module requires a sim card with a data subscription. The availability of 3G broadband service is broader compared to Wi-Fi, as 3G service does not require access points (AP), but base stations which are located at most places [17]. The module relies on the Global System for Mobile Communications (GSM), which provides continuous Wi-Fi connection to the system all the time. At this point, one must have understood that the system is valuable and operable only when it is provided with a proper internet connection. Internet connection is of paramount importance for transmitting collision information to the cloud database without any interruptions. On the other hand, it must be taken into account, that this collision system is not a tool that stays in a fixed position for a long period of time, but it is placed in a vehicle, which moves from a place to another frequently. Drivers and passengers would be in great danger if the system is not in proper function during a journey. In such a case, the system would definitely be in operation with continuous internet connection.

## III. Results and Discussion

### *A. Least Vibrating Portion*

The proposed system is intended to be placed somewhere in the interior of a vehicle to prevent the system from discovering unwanted vibrations caused by air resistance and being exposed to excessive heat. However, the interior of a vehicle can also provide unintended vibrations created by human activities. Movement of a car in forward as well as in reverse direction, on a flat road without any steep climbs, involves positive and negative x-axis only. Therefore, accelerometer readings at x-axis are only considered in the design. A study was carried out using the proposed system to determine the least vibrating portion in a vehicle. A Nissan Sentra facelift 2008 SG 1.6, which has kerb weight of 1280 kg, was chosen for this study. It was estimated that any segment, at the right-centre of a car, may create the least vibration, as it is the only point that is away from major electrical control mechanisms like engine, speakers, and tires. The system was placed at three different segments of the car such as front panel, storage box, and rear segment, to obtain accelerometer readings at each of the portions. Finally, the obtained values in the database were used to plot graphs of acceleration versus time with the help of MATLAB computing environment and SQLite database engine.

The result of the study shows that the vibration level on storage box, is somewhere between 7 $m/s^2$ and 11 $m/s^2$, whereas acceleration level at front panel and rear segment rise and fall between 5 m/s$^2$ to 13 m/s$^2$. It was summarized that the storage box contributes the lowest level of vibrations compared to that of the front panel and rear segment. Therefore, the suitable portion to place the proposed system is in the same position as of the storage box.

*B. Avoidance of False Notification*

Initially, it was discussed that human activities can cause vibrations that the system may detect, results in false detection. This matter would lead to inaccurate notifications of collisions to the concerned authorities, which cause the waste of a huge amount of time and anxiety. In order to avoid any false detection by the system, an experiment was carried out, where three different human activities such as door slamming, going over a speed bump and sudden break were chosen at random. A car, Nissan Sentra was driven in a street road with a velocity of 70 km/h, after placing the system in the interior of the car. As an exemption, the door slamming experiment was only carried out while the car was static, whereas the other two activities were conducted when the car was in motion.

The results of the study showed that all the three human activities trigger acceleration readings within a range of –40 m/s$^2$ to 20 m/s$^2$, which is way greater than the provided acceleration readings during the collision, shown in the previous section. As been discussed, the system will only alert the concerned authorities once the accelerometer provides an acceleration of less than −82.701 m/s$^2$. In fact, this creates a relationship between weight and deceleration, where the greater the weight of a vehicle, the greater the deceleration it provides after a collision.

*C. Collision Test*

In order to prove the performance of the system, it must be present in an automobile that collides at a speed of 70 km/h, with another car. Creating an exact copy of an accident with automobiles is not practical but it is possible to replicate one. Based on the theory of Inelastic Collision, the final velocity of a vehicle after a collision is calculated based on the weight of involved vehicles and the initial velocity the vehicles travelled in.

An example in which two automobiles with the weight of 1420 kg each, travel toward each other from the opposite directions in 70 km/h was chosen. The acceleration produced by the vehicle after the collision will be computed using the equation of momentum shown in Eq. (3) and Eq. (4). It was found that, when any objects that have the same weight collide with each other at the same initial velocity, the final velocity will become zero due to the cancellation of weight and velocity of each other. This leaves the calculation of acceleration to rely entirely on the initial velocity of the objects and time taken for the collision to occur. Therefore, the particular collision is very much possible to be duplicated using any amount of weight. A weight that weighs approximately 5 kilograms, was constructed using bricks and trolley together with the system. The system was tightly tied to the trolley so that it remains stationary relative to the trolley during motion. Later, the set-up was pushed towards a wall, to observe the deceleration it produces once it hits the wall. The distance between the wall and the position on which the set-up is placed is five meters. Figure 3 shows the measurement of the distance between the set-up and the wall.

Fig. 3. Distance between the set-up and wall.

The time taken for the set-up to reach the wall was measured using a stopwatch. After many attempts with higher amount of forces applied to the set-up, the minimal time duration that can be possibly achieved by it to reach the wall is 0.29 s only. Based on the obtained value, the initial velocity of the set-up was computed. The result showed that the set-up actually travelled at around 62 km/h, which is closer to the expected value. Later, the deceleration produced once the set-up hits the wall was determined as –86.207 m/s$^2$. Initially, the system was designed to send accident notification to the android application, if the produced acceleration value is less than –85.739 m/s$^2$. Figure 4 shows the inner construction of the system with various sensors.

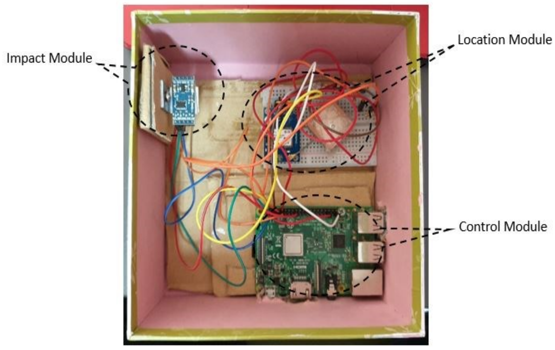


Fig. 4. Construction of life case.

In Fig. 5, the execution of the system encompasses detecting a huge level of in-vehicle vibrations and extracting the exact location of an accident, which will be sent to an android application via a cloud database. The produced acceleration value once the set-up hits the wall is shown in Fig. 5. Each vertical line with multiple dots represents an attempt. There is a total of eight attempts. The points that are closer to each other denote acceleration values during the motion of the set-up, whereas the only point at the right bottom of the line depicts the acceleration which is provided, once the system hits the wall. The last points that did not exceed the threshold value, show that the system was not pushed as hard enough to reach the expected velocity.

However, out of eight tries, three of them were successful. During the first attempt, at 12.47 pm, the system produced an acceleration value of –114.9 m/s$^2$, which tells that the set-up travelled at a velocity of 22.98 m/s, which 82.728 km/h. This is more than expected, which occurred due to the higher amount of force applied to the set-up. This is considered a successful attempt because it actually sent an accident notification to the android application. Collision was also detected at 12.56 PM and 12.58 PM. The variation in the velocity, which provided different accelerations, is due to the inconsistent amount of force that was applied to the set-up. Physical strength may fluctuate as time goes by.

However, the experiment has provided favourable results, since the system did send accident notification to the android application when the acceleration values are less than the restricted value.

*D. Network Connectivity Test*

A test was performed using the system prototype, to prove its ability to operate in all areas including cities and rural areas, in accordance with the availability of public hotspots or Wi-Fi. Initially, an android application by an Internet Service Provider (ISP) in Malaysia, was downloaded. The application offers the list of Wi-Fi hotspots around the country. One of a well-known city in Malaysia, known as Seremban in which the study was conducted. To begin the study, a few roads near housing areas, which are not available with public hotspots, were selected at random. An automobile consisting of the system was driven along the roads to ensure it is able to operate without the presence of Wi-Fi. The equipped 3G modem must be able to provide continuous internet connection to the system. The main objective of the study is to ensure the system is able to send accident notification to the android application once collision is detected.

Table III. Results of connectivity test.

| Location | Public Hotspots | Latitude | Longitude |
|---|---|---|---|
| Jalan Tuanku Jaafar Utara | No | 2.673416 | 101.994477 |
| Jalan Tampin | No | 2.668963 | 101.993374 |
| Jalan Dato Hamzah | Yes | 2.721717 | 101.942908 |
| Jalan Dato Bandar Tunggal | Yes | 2.721437 | 101.939825 |

The system was able to operate in four different locations without any network interruptions. The locations include two Jalan Tampin, Jalan Tuanku Jaafar, Jalan Dato Hamzah and Jalan Dato Bandar Tunggal. Jalan Tuanku Jaafar and Jalan Tampin, are not available with Wi-Fi hotspots whereas the other two places are equipped with public hotspots. The latitude and longitude of each place

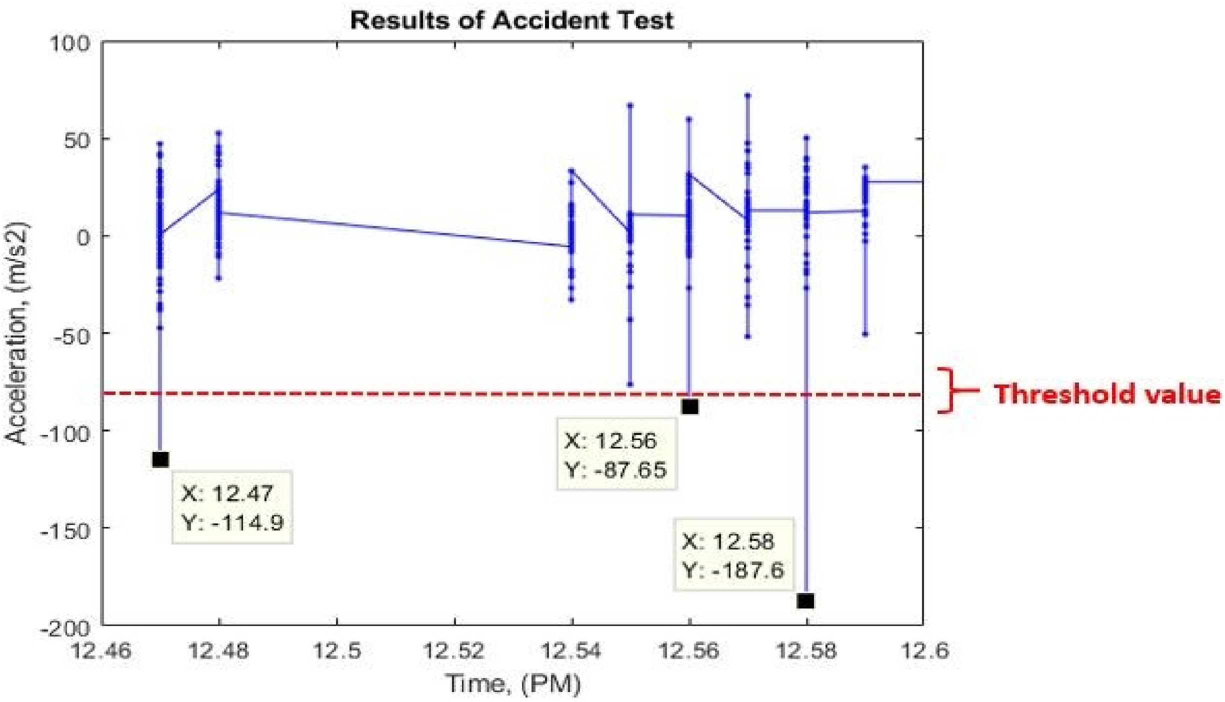


Fig. 5. Produced acceleration values during collision experiment.

In order to confirm the communication between the designed system and android application, the cloud database was observed for the presence of data. In fact, the automobile was driven in busy roads that are equipped with public hotspots. This is to prove that the system utilizes the public hotspots rather than the 3G modem. After the automobile was driven on the roads, the cloud database was checked for the presence of data. The database is checked each time after the automobile is driven on a specific road. It was found that the latitude and longitude of the roads or nearby places are sent to the cloud database, which is displayed using the android application, on a smartphone. The longitude and latitude in the cloud database are recorded each time when the automobile passes by each of the roads. The results are shown in Table III.

were transmitted to the cloud database, which shows the activity of the system.

*E. Android Application*

In the case of an accident, the developed android application pops up notifications with android sounds to alert the user. Besides, the main interface of the application consists of Google MAPS, on which a marker pinpoints the exact location of an accident spot. The exact position of an accident spot is displayed together with a pop-up window, which consists of two buttons. The buttons are for the user to confirm the validity of an accident.

Once the application retrieves the accident data, it immediately pops up a notification at the android notification window with an alert sound. The main user interface of the application displays the Google Maps, on which a marker points at the accident location together with a pop-up window. The selection of either button will print a toast message at the bottom of the smartphone, to inform other connected clients about the status of collision. Figure 6 shows the user interface of the android application.

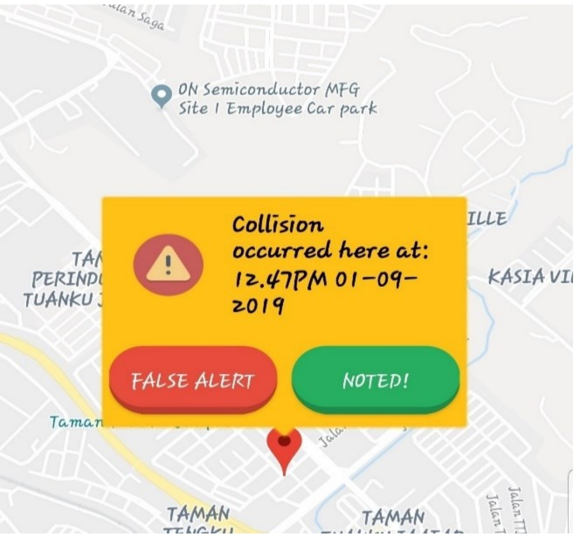


Fig. 6. User interface of collision application.

## IV. CONCLUSION

This paper discussed a system that, in the case of an accident, can alert the concerned authorities to save the accident victims on time, and is able to operate even in the absence of Wi-Fi service. Existing works on accident detection systems have exhibited certain limitations, which have been overcome by the insertion of a few design elements in Life Case, which includes the incorporation of 3G services for extended network coverage.

The development of an android application, to which accident data is sent to through a cloud database, has improved the effectiveness and reliability of the system in certain aspects, which entails protection of data, avoidance of spam, notification of accidents, discovery of the exact geographical position of an accident spot and procurement of large degree of attention from the people towards accidents. The system prototype was used for the experiments to observe the difference in the level of in-vehicle vibrations, of which the results assisted to determine the least vibrating segment in the interior of an automobile to avoid false detection of accidents created by human activities like door slamming, movement of car over a speed bump and sudden break. A weight was constructed together with Life Case to conduct an Accident Test, to make sure the system sends an alert notification to the android application once the system provides acceleration values less than -85.739 $m/s^2$. A Network Connectivity Test was also performed to observe the operation of Life Case in places that do not have Wi-Fi connectivity. Therefore, Life Case is an effective and reliable system that is in a ready state to be incorporated in the real world scenarios.

## V. FUTURE WORKS

The system can be enhanced in terms of efficiency and reliability. Firstly, automotive battery can be connected to the system for power consumption, rather than relying upon power banks or rechargeable battery. Secondly, a GPS Module with a superior receiver is recommended to be integrated with the system, for better discovery of location, especially indoors. In order to receive the thin GPS signals from the satellite, a good GPS receiver is very much needed, or else, the system can only operate in open space. Finally, further researches have to be carried out to extend the system to support other vehicles such as motorcycles, bus, and truck.

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