FINAL YEAR PROJECT 2

Dissertation (1st Draft)

Automated Accident Location Detection System (Extended)

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CERTIFICATION OF APPROVAL

Automated Accident Location Detection System (Extended)

by

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Approved by,

____

(DR. JAFREEZAL BIN JAAFAR)

UNIVERSITI TEKNOLOGI PETRONAS

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own expect as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(EDDY GOH TIK EARN)

ABSTRACT

Today, the human rely more on automobile road transportation compare to the other transportation medium. Therefore, the more road users on road will causes increasing number of accidents happened. This problem has increase the fatal rate of accidents. Although the Malaysian Emergency Response Services team (MERS 999) has implemented in Malaysia to provide support to accidents, but there are several inefficiency usage of resources in the organization. The scope of study will be based on the Malaysian drivers only. The author is extending the project from the previous final year student. He will be continuing to do the server gateway, website system and implementation of algorithm in Automated Accident Location Detection System. The project is rapidly tested and verify to ensure it is on the right track and to meet the deliverable deadline. Surveys were done to 120 respondents who are car drivers. The results show a positive result towards the objective of this project. The overall result recorded a 2.66 of ratings out of 5 on the efficiency level of MERS 999. Qualitative research is carried out on 3 of Malaysian driver and 1 staff from MERS 999. The functionalities of this system will enhance the current emergency response service by providing a platform for reporting an accident. The accident locator and website system will work together to redirect the real-time message to the nearest hospital using the modified Haversine algorithm. This will help to reduce the fatal rate as stated in the objective.

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1. INTRODUCTION

1.1 Background of Study

Today, human relies on automobile transportation more than all other public transport such as train, bus and airplane. The automobile transportation is essentially synonymous to all the people around the world. All office building, shopping complex and residential area are built with the priority of automobile transportation accessibility like multilayer parking. In Malaysia, motor vehicles transportation recorded the highest percentage compared to other transportation method. In year 2010, total motor vehicles transportation is recorded as 20,188,565, which is a very high ratio to the population of Malaysia. (Ministry of Transportation, 2010). Furthermore, increasing usage of motor vehicles transportation causes increasing number of road accidents. The statistic from Ministry of Transportation (2010) recorded an average of 3.766% accidents rate for motor vehicles transportation and an average 1.885 % of fatal rate in all accidents from year 2001 to year 2010.

By looking at the current process flow of emergency reporting system, there is plenty of time wasted while the information is being transferred to another party. The time delay in the process would cause the victim to encounter excessive blood lost and blood clot in the injury area. This greatly increases the probability of fatal rate in each of the accidents happened in Malaysia.

The activity in the current accident reporting system is started by calling the emergency line which is 999 and the operator will redirect the call to the nearest hospital after description of current location by the caller. This whole process creates a very long delay between the time that the accident and the arrival of rescuing effort. By referring to The Star (2012), the operators at MERS 999 answer each of the call within 20 seconds. This time period is excluding the explanation of the accident location by the caller. This will take another few minutes which will cause the fatal rate to increase.

According to the statistic from Ministry of Transportation (2010), year 2009 recorded 1.70% of death rate out of 397,330 total numbers of accidents while year 2010 recorded 1.66% of death rate out of 414,421 total numbers of accidents which are very high. These percentages can be lowered down if the emergency reporting process is reviewed and enhanced.

Therefore, by providing instant emergency rescue effort to the victims who involved in the road accident, the fatal rate can be greatly reduced. This point has inspired the author to continue the project started by the previous final year student, to complete the whole system prototype “Automated Accident Location Detection System” that will help reducing the fatal rate in road accident.

Therefore, with all the review from all the other parties, the title proposed for final year project is “Automated Accident Location Detection System”. The system detects vehicle accident location and sends notification to the hospital for instant rescuing effort to the victim. The system is separated into two parts: vehicle accident detector and website location system. The vehicle accident detector is done by the previous student of the supervisor and author will continue on the website location system.

The vehicle accident detector scans the X, Y and Z axis of the vehicle for possible car accident and trigger the Global System for Mobile (GSM) to send out the information to the server, while the website location system is to retrieve the location, car plate number and other details from the GSM and GPS machine in the vehicle and process it so that the accident information will be routed to the nearest hospital for rescuing effort. The system will calculate using the incremental method for getting the nearest hospital from the current GPS coordinate. It will choose the hospital with the lowest distance and send the routing data to the particular hospital system. An alarm will be triggered and the hospital will send their crews for rescuing. The nearest location calculation will be based on the specify radius preferred in KM. The hospital can either attend to the alarm or the system will route it to the second nearest hospital for further action.

1.2 Problem Statement

There are 3 problem statements in this project as listed as the following. For the current safety products installed in the motor vehicles, there are insufficient safety features such as airbag and enforced front hood of the car could save a victim from a severe accident. The only help from those safety features are to reduce the injury to the minimum level, but for other severe accidents, immediate medical attention would help to reduce the fatality rate of all victims in car accidents. Normally, the victims are not able to make a call or report to the hospital for help when they involved in an accident.

Due to some communication gap of reporting an accident, there is a long delay between the accident happened and the rescue effort from the hospital. The people who report the accident will take time to explain the accident location to the emergency operator for redirecting the call the respective nearest hospital.

The verbal explanation about the accident location with description of the landmark and signboard creates a chance of misunderstanding the location when there are no landmarks or signboard available for references. The current way of contacting the emergency line is verbally by telling the addresses and location of the accident would take up to 5 minutes. The time gap of the communication will slow down the rescuing effort and will cause increasing fatal rate in accidents. This is because excessive lost of blood or blood clot after the accident which will cause probability of death to increase, unless immediate medical attention is provided by the hospital.

1.3 Objective and Scope of Study

The main objective of this project is:

- To study the current process flow of emergency reporting and rescuing.
- To develop a system that is able to speed up the process of reporting the accident to the hospital and insurance company.
- To test system for efficiency and performance.

The scope of study is mainly on the motor vehicle road transportation accident (car accident) only. One of the scopes will be reviewing the current reporting systems and its effectiveness. The target user would be those who are driving motor vehicle which as known as the car driver. All the studies about the road transportation, the statistic and all the process flow are being retrieved only if they are related with Malaysia context. The study will focus on revolutionizing the process flow of the information flow from the real time accident to the MERS 999 for rescuing effort. The parties that will involve are the hospital, police, insurance company and the emergency contact whoever the victim set.

All the related technical area are on the automobile accident detector, implementation of GSM to the detector, MYSQL query to calculate the nearest hospital to the accident location and the algorithm to redirect the incident to the nearest hospital in a web system.

For this project, author has used the programming fundamental skills learned in the university in order to complete the project. All the notes and slides are used as the references while developing the website and database query. This is where author can apply the theoretical knowledge as stated in the FYP guideline.

1.4 The Relevancy of the Project

This project is relevant to Malaysian car driver. It is because all car drivers are exposed to the same risk of involving in an accident. Some severe accidents injuries are unable to prevent by the safety feature provided in the vehicles. Therefore, the system will provide the after accident medical support to further reduces the fatal rate.

The project is also important to the hospital as it provide a platform to replace the current emergency hotline 999 which is time and resources consuming. With the assistance of this system, all hospitals are able to maximize their resources by sending immediate support to help the victim who involves in accident.

The objective of this project is to study the emergency reporting and rescuing system. This objective is relevant to this project as it provide adequate information about the time and the process flow of the current emergency reporting system. With the information from the study, it will help to improve and modify the current process flow to achieve the best speed to report an accident. This can help to increase the safety of all car drivers by providing instant medical rescuing effort. The system will be tested for efficiency and performance which will ensure that it operates as quick as possible every time an accident event is triggered.

1.5 Feasibility of the Project within Scope & Time Frame

The Automated Accident Location Detection System (AALDS) is continued from the previous Final Year Project student. This project is recommended by the supervisor as it contributes a lot of value to the society.

Due to the time constraint, the project has to be scope down to ensure the deliverable can be complete on time. The system is divided into 2 parts which are the accident detector device and the website server as an interface. The accident detector device is 90 percent done by the previous Final Year Project students. The author will be extending the project by connecting the accident detector device to the server and the website interface for full functionalities. The project can be speed up by the help of several programming lecturers from Universiti Teknologi PETRONAS which give guidance and ideas on how to code the system.

Furthermore, the project will continue even though there are holidays and semester break to ensure the deliverables can be completed on time. The author has discussed with the lecturer to attend a few programming class to help to boost up the speed of coding the system.

The project is scoped down to Malaysian context only. Therefore, the author can retrieve the information easily from a focus target of knowledge pool.

The project is planned carefully to ensure all the activities can be done before the time frame.

2. LITERATURE REVIEW

2.1 Airbag System vs. Pervasive Fall Detection

According to Farmer (2003), airbag system is to reduce the injury of the driver and passenger during crashing in an accident. The benefits of airbag system are low cost, high reliability and have accuracy of approximately 95%. (Farmer, 2003). After the implementation of airbags in automobiles, there is a 14 percent of reduction on the fatal rate. (Basavaraju, 2009). According to Basavaraju (2009), the airbags system is designed for serious frontal crashes only, it avoid the driver and passengers to hit the dashboard or steering in front of them in the vehicles. It provides extra safety measure in addition to the traditional safety belts by preventing the occupants to hit any object of the vehicle interior. The airbags system is responsive to frontal or head-on collision only and it has only a very low level of effect on the side collision crash. This means that the vehicle unable to detect a collision if the hit area is non-frontal. Figure 1 shows the demo of an airbag collision, while Figure 2 shows the side view of the car crash with airbag.

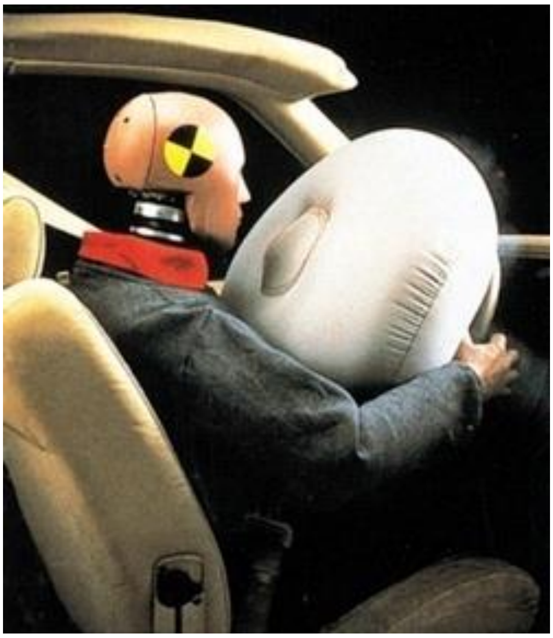


Figure 1: Airbag collision demonstration

Source: Retrieved from http://blog.electricbricks.com/wp-content/uploads/airbag.jpg

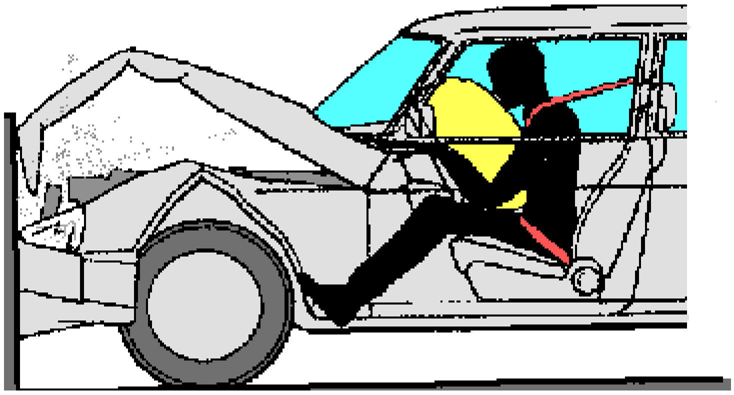


Figure 2: Airbag crash diagram example

Source: Retrieved from http://www.aa1car.com/library/airbag_crash.gif

As compare to the pervasive fall detection which used as a device to detect an unavoidable fall of an elder people, it uses the X, Y and Z-axis reading from accelerometer to indicate if a fall is happened, this method can ensure any impact from any direction can be detected. (Dai, Bai, Yang, Shen & Xuan, 2010). A threshold of value will be set in the software part of the pervasive fall detection system to effectively detect the fall of an elder people. The

2.2 Automatic Accident Detection with Sensor Technology

According to Lakshmi and Balakrishnan (2012), the automatic accident location detection system has reduced the warning time of the accident and determined the location of the accident. The fully automated location detection and information distribution to each of the nearest hospital will earn a valuable rescue time. It reduces death rate in road transportation and speed up the process of reporting the accident to the authority. (Lakshmi & Balakrishnan, 2012). Furthermore, the detection module would able to detect the false alarm which can avoid false information sent to the hospital. It can detect the sudden change in the reading of X, Y and Z-axis reading in the accelerometer which can effectively detect the accident information of the automobile compared to the traditional airbags system. (Lakshmi & Balakrishnan, 2012). Figure 3 shows the example of the system software flow chart of the automatic accident detection with sensor technology. The system will start by checking the status of the system and repeatedly scan for the acceleration detection from the accelerometer to trigger the accident alarm. Then the system will retrieve the GPS coordinate of the current location and send out to hospital.

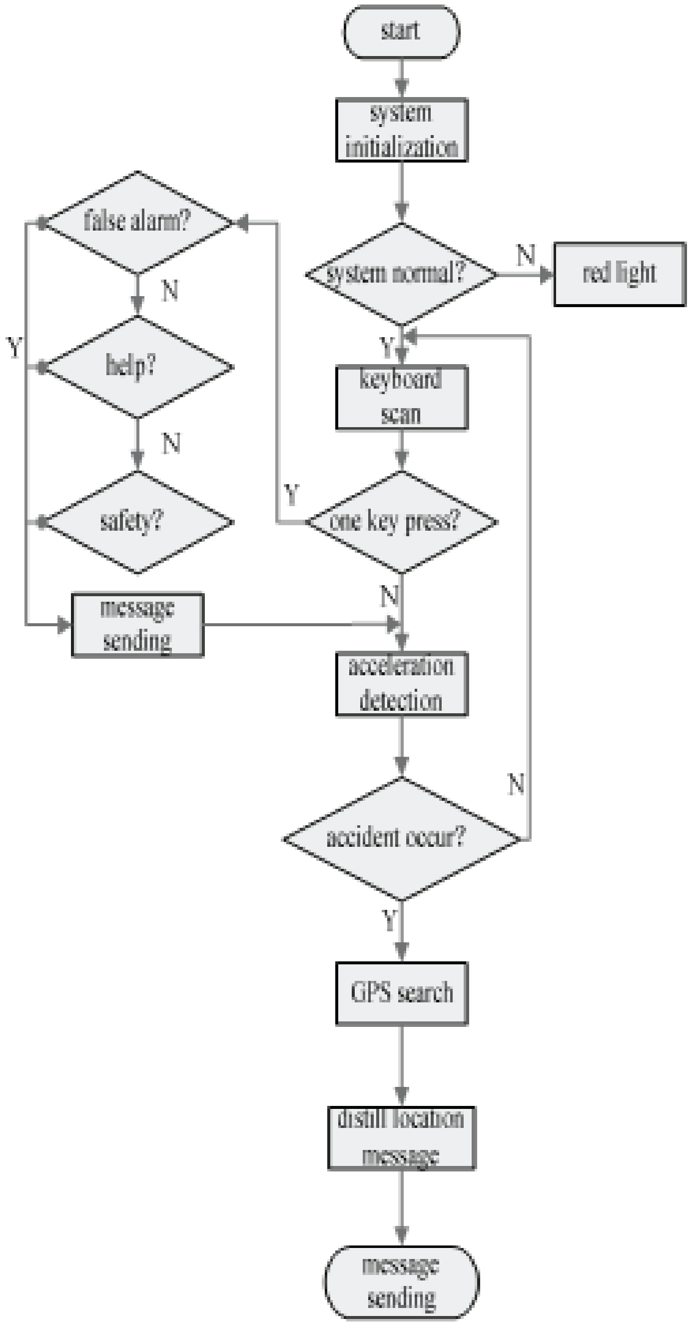


Figure 3: System software flow chart of the automatic accident detection with sensor technology

Source: Automatic Accident Detection with Sensor Technology by Lakshmi & Balakrishnan (2012)

2.3 Malaysian Emergency Response Service (MERS 999)

Malaysia Emergency Response Services (2013) stated that 999 is an effort done by the Malaysian government to integrate all the emergency number service system in Malaysia for efficiency. The system is running under a common platform for providing a consistent and uniform emergency call handling process. Under the command of government, all the emergency bodies will carry on their tasks respectively such as, police, fire department, hospital and civil defense department. The system provides details of the callers to the emergency service provider. Figure 4 shows the logo and poster of MERS 999.

Figure 4: Logo and poster of MERS 999

Source: Malaysia Emergency Response Services (MERS) 999 website retrieved from http://www.999.gov.my/

According to Kurnia Insurance (2013), among the top priority of the procedure of what to do in the event of accident is to make a call to emergency operator at 999 if there is any injury in the accident. According to The Star (2012), Malaysia Emergency Response Services (MERS) 999 has created a new benchmark to follow the benchmark of the United State emergency operator which is to answer the emergency call within 20 seconds, 10 seconds faster than the previous benchmark. Information, Communications and Culture Ministry secretary-general Datuk Seri Kamaruddin Siaraf said that the government decided to implement the benchmark together with the Government Transformation Program to increase the efficiency of handling emergency call. They also ensure that the emergency operators have the soft skills on how to handle the phone calls such as asking for the location and the condition of the accident. (The Star, 2012). Even with this benchmark implemented, the process of current emergency operator is significantly slow, as it needs 20 seconds for only picking up an emergency call.

According to New Straits Times (2010), the MERS 999 answered the emergency call within 4 rings or less than 10 seconds. “We respond within eight minutes, which is half the national response time of 15 minutes.” (New Straits Times, 2010). The MERS 999 in Cyberjaya received about 15 calls every day from the public. Therefore, the fastest time period for an emergency team backup to the accident location is around 8 minutes. Within this 8 minutes there are chances that the victims are fainted and passed away due to excess lose of blood. Furthermore, this great performance achieved by MERS 999 is only applied to Cyberjaya where is equipped with hundreds of CCTV for real time escalation. The area also included a lot of police officers to detect all type of potential events. Therefore, this has proven the best time for the authority to respond to the accident at the very moment it occurred would be 8 minutes with all the equipments and resources invested. If the areas other than Cyberjaya, the time recorded will be more than 8 minutes as the working police and resources are very less compare to Cyberjaya.

Figure 5: Example of CCTV used by MERS 999 to surveillance the surrounding

Source: Retrieved from http://www.frontline-fs.com/wp-content/uploads/2012/07/CCTV2.jpg

According to MERS 999 (2012), 999 systems are integrated with closed-circuit television (CCTV) in Cyberjaya and Putrajaya for a safer city (MSAFE). Figure 5 shows the example of CCTV used by MERS 999 to surveillance the surrounding in Cyberjaya. The government aspiration towards the concept of 'Malaysia Safe City', Cyberjaya and Putrajaya were chosen to be the pilot for the implementation of the concept. CCTV systems and system integration 999 (MSAFE) has been successfully implemented in Cyberjaya (June 2009) and Putrajaya (2010). The advantage is not only in the identification of the caller's details, but it also allows the police to see the scene of the incident in real time with applications that show distance, height, and size of polygons architecture surrounding area. (MERS, 2012). This allows the emergency services sent to the scene almost as well. MSAFE system is fundamental to improving public safety in Malaysia. All these efforts done by MERS 999 can be greatly reduced if the system of emergency hotline 999 can be improved. All the CCTV and resources are not worth investing.

Ir. Rozinah Anas (2012), the project director of (Malaysian Emergency Response Service) MERS 999 said that MERS 999 is a system that integrates all the Malaysia’s core Public Safety and Emergency Agencies through a single line number “999”. The common team includes the fire and rescue department, police department and hospital. The idea of 999 is referred from the foreign countries emergency line which is 112 to provide instant rescue service to the public. One of the companies in Malaysia, Telekom (TM) has appointed to form the MERS 999 for servicing on behalf of the government. (Rozinah, 2012). The diagram shown is the MERS 999 call flow when they receive an emergency call.

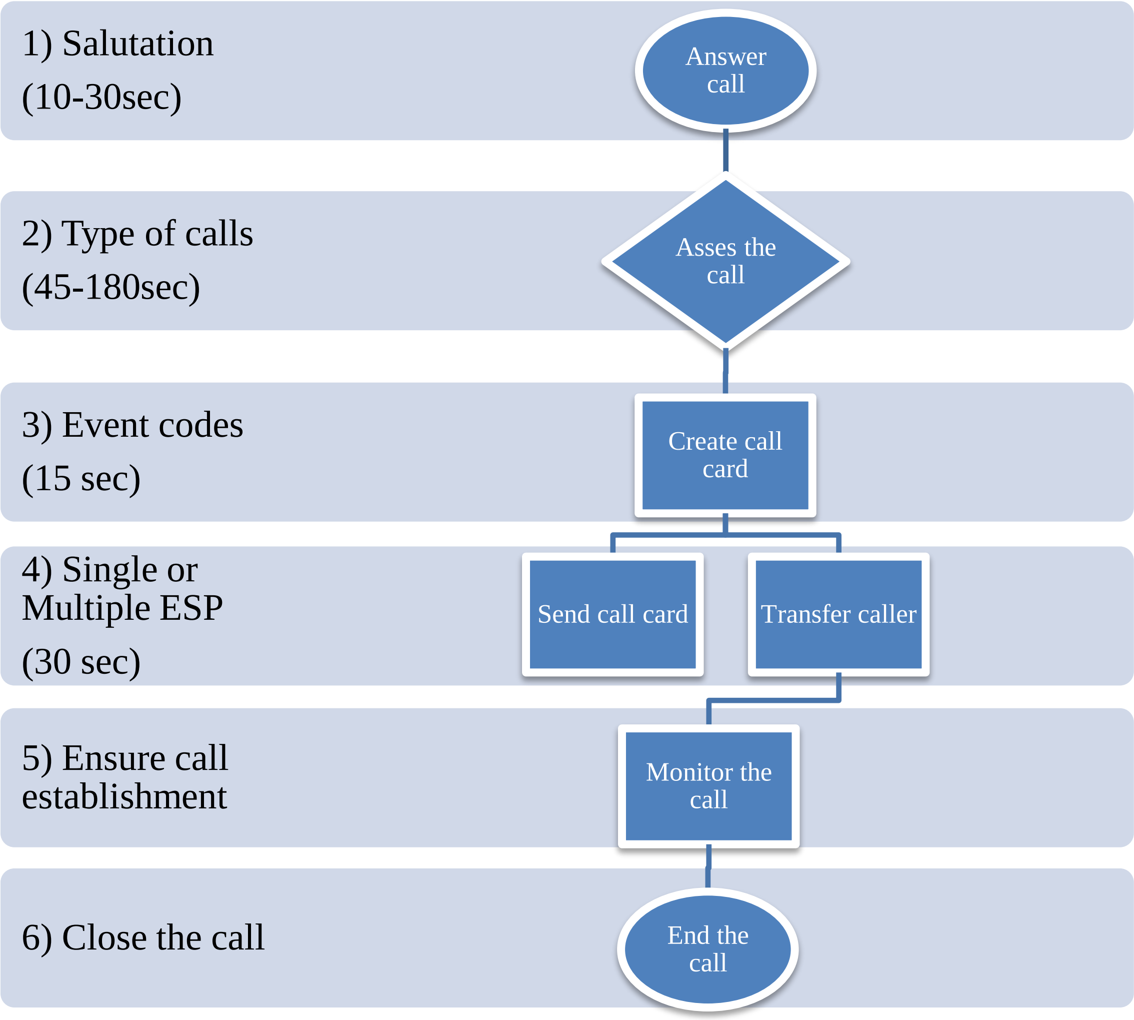


Figure 6: Call taking process at 999 response center

Source: Retrieved from http://www.mygeoportal.gov.my/sites/default/files/ngis5/Kertas%201%20-iv%20Ir.%20Rozinah%20(TM).pdf

By referring to Figure 6, the emergency operator answers the call with a salutation such as “Emergency, may I help you?” Then the operator will apply the call procedure set by MERS 999 to assess the type call. The important information such as the type of incident, the location of the incident, the name of the caller and the contact number of the caller are being asked. After that, the emergency operator will create the procedure (call card) and states the event codes from 14 predefined event codes. The call card will then send to respective department or transfer the caller to talk with the related department such as the hospital. The emergency operator will ensure the call establishment after transferring the call. Finally, the operator ends the call. According to the citation above, to start of the first action which is answering the call would need 20 seconds. (The Star, 2010). Then, to assess the call, create call card, transfer the call card and send the rescue team to the accident location would need about 15 minutes in a very optimal measurement. (New Straits Times, 2010). The flow chart of 999 response centers is too lengthy which slow down the effort of providing rescue to the victims. According to The Star (2010), responding speed of the emergency operator team of MERS 999 has been greatly improved by providing trainings and increasing the number of operator, but there is maximum limit speed can be achieved. An additional improvement needs changes on the flow chart and the way to transfer the real time information of any accident happened on the road. Skipping the whole verbal calling process and replace it with an electronic communication will be greatly reducing the time buffer between the messages flowing from the real time accident to the authority. The approximate time range taken for each processes are listed in Figure 6.

2.4 Global Positioning System (GPS)

Global Positioning System (GPS) is normally used to detect the location by detecting multiple satellite signals and calculate the coordinate information using some algorithm. (Thompson, n.d.). The GPS signal is broadcast from 29 of the satellites simultaneously and normally only 8-12 satellites visible for detection from some coordinate on earth. (Taqiyuddin, 2009). This can save time from explaining a particular location according to landmarks or signboard. Currently, GPS is used for navigating system by integrating the map data which is not a part of a GPS system. The associated technologies bring the two systems together and form a navigation system. (Thompson, n.d.). Navigation system enables human to locate themselves on a map and the appropriate software will dynamically calculate the path from point A to B, the more advance software will dynamically calculate the estimate time arrival by measuring the level of traffic congestion. Figure 7 shows the GPS satellite constellation image. It shows the US and Chinese navigation satellites.

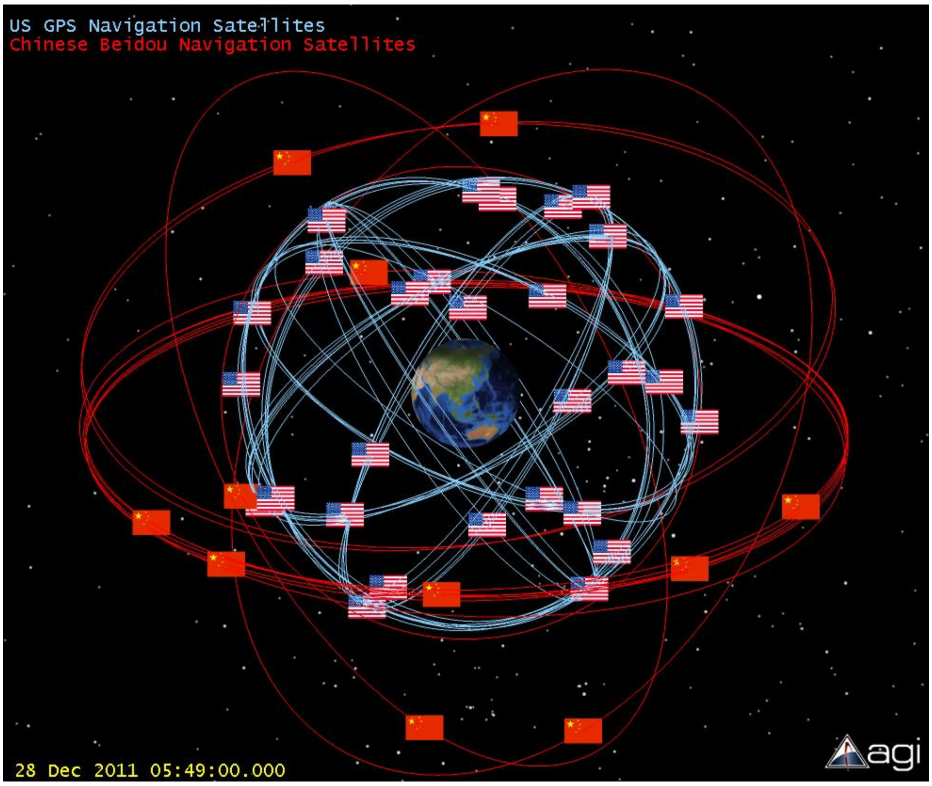


Figure 7: GPS satellite constellation image showing the US and Chinese navigation satellites

Source: AGI Corporate Website retrieved from

http://blogs.agi.com/agi/wp-content/uploads/2011/12/US_China_Navigation.bmp

2.5 Distance Calculation Algorithm

All the distance information is calculated using Google Map API V3. The Haversine formula is used to calculate the distance between two coordinate on earth in Google Map API. (Google Maps API, 2012).

Any surface of an object can be represented by polyhedral approximation. By increasing the resolution or the number of vertices, the approximation of the distance can be done more accurate because of a more complicated data collection. (Zhao & Lan, 2010). In the algorithm of splitting, the complexity will be greatly reduced and able to speed up the process of executing query on any database. According to Zhao and Lan (2010), to calculate the shortest distance between convex polyhedral, the curved surface is divided into smaller parts. This reduces the operation in the calculation to retrieve information from the database which by reducing the search node it has to be reached and improve the real-time execution period. (Zhao & Lan, 2010).

Figure 8: Different split layers rendering

Source: A Fast Collision Detection Algorithm Based on Distance Calculations between NURBS Surfaces by Zhao and Lan (2010), retrieved from http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6188231

The rendering example in Figure 8 shows that the tea pot is divided into a lot of parts to make sure the final product of the tea pot would be smooth when the number of vertices is increased to infinity. This can be implemented in the formula of searching the nearest hospital by dividing the radius into a smaller parts and start searching. Zhao and Lan (2010) proved that this method can increase the speed of processing in the computing machine.

There are a lot of ways to calculate the distance between point A and point B on the surface of the Earth by referring to the latitude and longitude provided. According to the Geoscience Australia (2013), the simpler the algorithm, the less accurate is the answer. Therefore, the accuracy of the distance calculation is depends on the complexity of the methods.

Table 1 indicates the terms explanation on the variables that will be used in the calculation of the algorithms. All the calculation will be done in kilometers as this commonly used in Malaysia.

Table 1: Explanation of terms for calculation

L1	=	latitude at the first point (degrees)
L2	=	latitude at the second point (degrees)
G1	=	longitude at the first point (degrees)
G2	=	longitude at the second point (degrees)
DG	=	longitude of the second point minus longitude of the first point (degrees)
DL	=	latitude of the second point minus latitude of the first point (degrees)
D	=	computed distance (km)

Source: Geoscience Australia retrieved from http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-techniques/distance-calculation-algorithms.html

In this literature review, there are a few type of algorithms will be reviewed as listed below:

- Great Circle Distance (Based on Spherical trigonometry)

  By referring to the spherical trigonometry, this method calculates the great circle distance and assumes that 1minutes of arc is 1 nautical mile and 1 nautical mile is 1.852km. (Geoscience Australia, 2013). The formula for calculating the distance by using this algorithm will be:

  D = 1.852 * 60 * ARCOS (SIN(L1) * SIN(L2) + COS(L1) * COS(L2) * COS(DG))

  All distances and angles, such as latitudes, longitudes and true courses will be assumed to be given in radians. (Williams, n.d.). The calculation done in radians will be much easier. Normally, the conversion is done before the calculation is started and the answer in distance will be converted back to natural unit we use daily. This formula will generate a lot of floating point precision. In a low floating point system, it will have a lot of rounding errors if the distance calculated is very small. For example, a kilometer of distance will results in 0.9999999 in the answer provided.

- Spheroidal model for the Earth

  According to Geoscience Australia (2013), "This method assumes a spheroidal model for the Earth with an average radius of 6364.963km. It has been derived for use within Australia. The formula is estimated to have an accuracy of about 200 meters over 50km, but may deteriorate with longer distances." Therefore, this formula is not recommended, as if a hospital is 25km away from the accident location, the accuracy will be as low as 100 meters.

Table 2: Spheroidal model for the Earth calculation

TERM1	=	111.08956 * (DL + 0.000001)
TERM2	=	COS(L1 + (DL/2)
TERM3	=	(DG + 0.000001) / (DL + 0.000001)
D	=	TERM1 / COS(ARCTAN(TERM2 * TERM3))

Source: Geoscience Australia (2013) retrieved from http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-techniques/distance-calculation-algorithms.html

- Haversine Formula

  Due to the high floating point precision needed in the previous algorithm, Haversine formula is recommended as it does not generate serious rounding errors for distance larger than a few meters. (Movable Type Ltd, n.d.). Haversine Formula is better for calculation ranging from small distance to great distance. (Gregory, 2010).

$$\Delta\sigma = 2\arcsin\left(\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos\phi_1\cos\phi_2\sin^2\left(\frac{\Delta\lambda}{2}\right)}\right).$$

Figure 9: Haversine Formula

Source: Gawley (2011) retrieved from http://www.thetubechallenge.com/projectplan/primarydatagathering/network-map

Although Haversine formula calculation for distance is accurate in most of the cases, but it will provides some strange rounding errors in the case of antipodal points, which means by calculating the opposite ends of the sphere. (Movable Type Ltd, n.d.).

- Vincenty's Formula

  This formula is the most accurate for all distances by taking into consideration of the rounding errors for antipodal points. The Vincenty's formula is the most generally method used to calculate distance between two specific points on ellipsoids. (Movable Type Ltd, n.d.). Figure 10 shows the equation of Vincenty's Formula.

$$\Delta\sigma = \arctan\left(\frac{\sqrt{(\cos\phi_2\sin\Delta\lambda)^2 + (\cos\phi_1\sin\phi_2 - \sin\phi_1\cos\phi_2\cos\Delta\lambda)^2}}{\sin\phi_1\sin\phi_2 + \cos\phi_1\cos\phi_2\cos\Delta\lambda}\right).$$

Figure 10: Vincenty's Formula

Source: Validation of Vincenty's Formulas for the Geodesic Using a New Fourth-Order Extension of Kivioja's Formula by Thomas and Featherstone (2005) retrieved from http://www.cage.curtin.edu.au/~will/thomas-featherstone.pdf

Based on the simulation done by Thomas and Featherstone (2005), the Vincenty Formula is used to calculate 3,800 lines of different coordinate and distance ranging from 10 to 18,000km and it turns out that the dispersion within each calculation is less than 0.115mm which is very small. "Vincenty's direct formula will give equally good results much more quickly". (Thomas & Featherstone, 2005).

Table 3 shows the comparison of the distances calculated by each of the methods. As a result, the Vincenty's formulae, is the most optimal formula to be used compare to others method. However, because of the speed needed in this reporting system, Vincenty's formula is not suitable for implementation.

Table 3: Comparison of distances calculated 3 different types of method

From	Method 1	Method 2	Method 3
To	Great Circle	Approx. ellip.	Vincenty's
A A	0.000	0.000	0.000
A B	111.120	111.089	110.861
A C	146.677	146.645	146.647
A D	241.787	241.728	241.428
A E	346.556	346.469	345.929
A F	454.351	454.237	453.493
A G	563.438	563.294	562.376
A H	1114.899	1114.616	1113.142
A I	2223.978	2223.420	2222.323
A J	3334.440	3333.612	3334.804
A K	4445.247	4444.156	4449.317
A L	5556.190	5554.843	5565.218

Source: Geoscience Australia retrieved from http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-techniques/distance-calculation-algorithms.html

As a conclusion on the best distance calculation algorithms is the Vincenty formula. However, Zdeb (2012) state that Haversine formula is the most recommended formula to be used in all the real world implementation nowadays. Although the accuracy of the distances calculated using this formula is lower than Vincenty formula, but it provides an acceptable accuracy for the public use. According to Hoyer (2009), the Haversine formula is considered very important trigonometric functions. It is used in many different fields in real life, for example, the Haversine formula is used by the Muslims to find the direction of their qibla. Furthermore, Google Maps will provide interactive solution to a lot of real world problems based on the Haversine formula. (Hoyer, 2009). The simple Haversine algorithm provides both accuracy and speed which other algorithm could not satisfy both of these criteria. (Zdeb, 2012). Google Map API V3 calculation will be based on the Haversine algorithm. Further accuracy and speed testing on the algorithms will be reported in result and discussion.

3. METHODOLOGY

3.1 Research Methodology

This project is more on a constructive research from testing the previous existing system and proposes a better solution to the current problem faced in reality. According to study and comparison on the existing system and the proposed solution, it would solve the weakness of the previous system by integrating several technologies such as, accelerometer, GPS, GSM, distance calculation algorithm and some internet programming theories.

There is quantitative study done by distributing the survey form to 120 Malaysian drivers to get feedback on the reaction when they involve in car accident. Furthermore, a few qualitative studies are done. Some of the driver is chosen randomly to get their comments about the system design and the preferred user interface. The interview will get feedback from the road user for improvement on emergency reporting and rescuing. The Figure 11 shows the visualization of the use of quantitative research and qualitative research in this project and the objective of each of the research done.

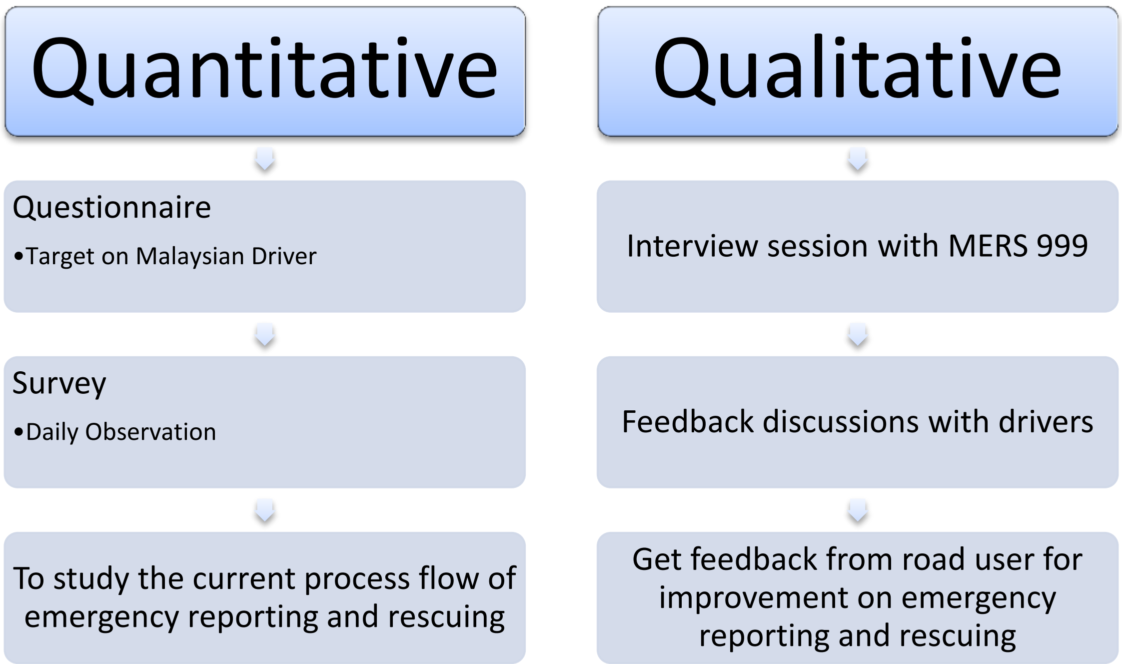


Figure 11: Visualization of the quantitative and qualitative research.

The project has some hypothesis created based on the research objective and it is tested and reported in the findings and results section.

The research on this project was done by discussion with supervisor – Ms. Penny Goh and Dr. Jafreezal Bin Jaafar and the previous student of this project. The design methodology used to complete the website location system is by using agile software development, a method which rapidly update and change the requirement of the system to fit in with the expectation of the stakeholders, in order to increase the reliability of the system to the user.

3.2 Design Methodology

Figure 12 shows the flow of one of the agile software development method used to complete the project which is Rapid Application Development.

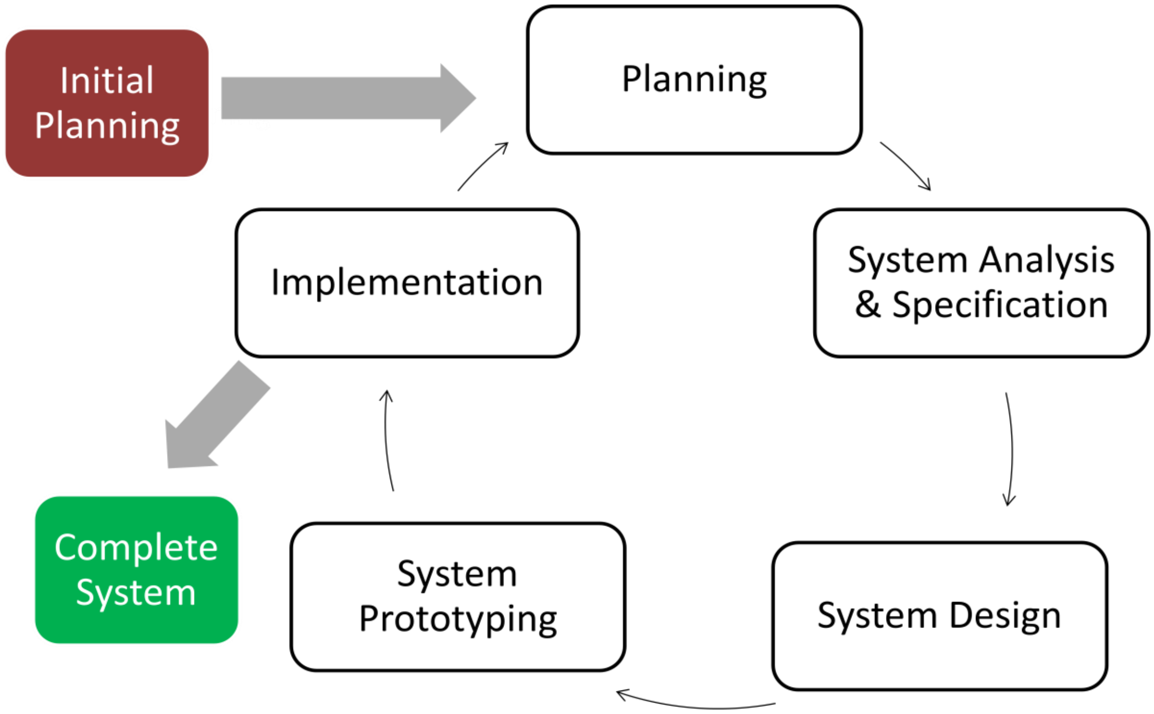


Figure 12: Software development agile lifecycle – Rapid Application Development

The project starts with an initial planning of what is the process of the whole project. Then, the activity will dived into the planning phase where all the tasks will be listed out and arranged into the key milestone and Gantt chart which will be showed in the later part of this project. Next, the project will continue to the phase of system analysis and specification. In this phase, the architecture of the system will be drafted out and specified the features and functionalities preferred by the stakeholders. The next phase will be the system design, where all the design tasks will be done here. All the interface design, the process flow, interface flow and the backend will be drawn out and coded for proof of concept only. The system prototyping will be carried out once the designing part is done by coding the real system. Then the partial code will be implemented in the mock up system for verification and debugging. The whole process is repeated until a complete system is published and produced. This will lower the cost of the project as all the constraints are flexible and able to be changed in the future.

The agile software development technique used is as following:

a) Test driven design
b) Continuous integration

This method is used as it gives a maximum flexibility for the author and the development of the project to constantly update and change the requirement of the project to meet the expectation by doing continuous experiment on the system created.

Test driven design is used as the iteratively writing of a single test and the sufficient production code is written to fulfill the test case. By implementing in small steps like this, the author can see whether the production code fulfills the new test.

Other than that, the system is being built/compiled/integrated on a regular basis, at least several times a day, and whenever source code is updated, the latest one will be checked into version control. When the code is changed, it will be recompiled and see if it is working under the real integrated environment.

The key milestone of the project is done according to each dateline set by the Final Year Project board in the guideline. There are several discussions with supervisors through meetings and emails to ensure the project is on track and fulfills the requirement of the supervisor. There are some inspection done by the supervisor occasionally to understand the concepts and ideas in the project.

3.3 System Architecture

Figure 13 shows the overall system concept of this project.

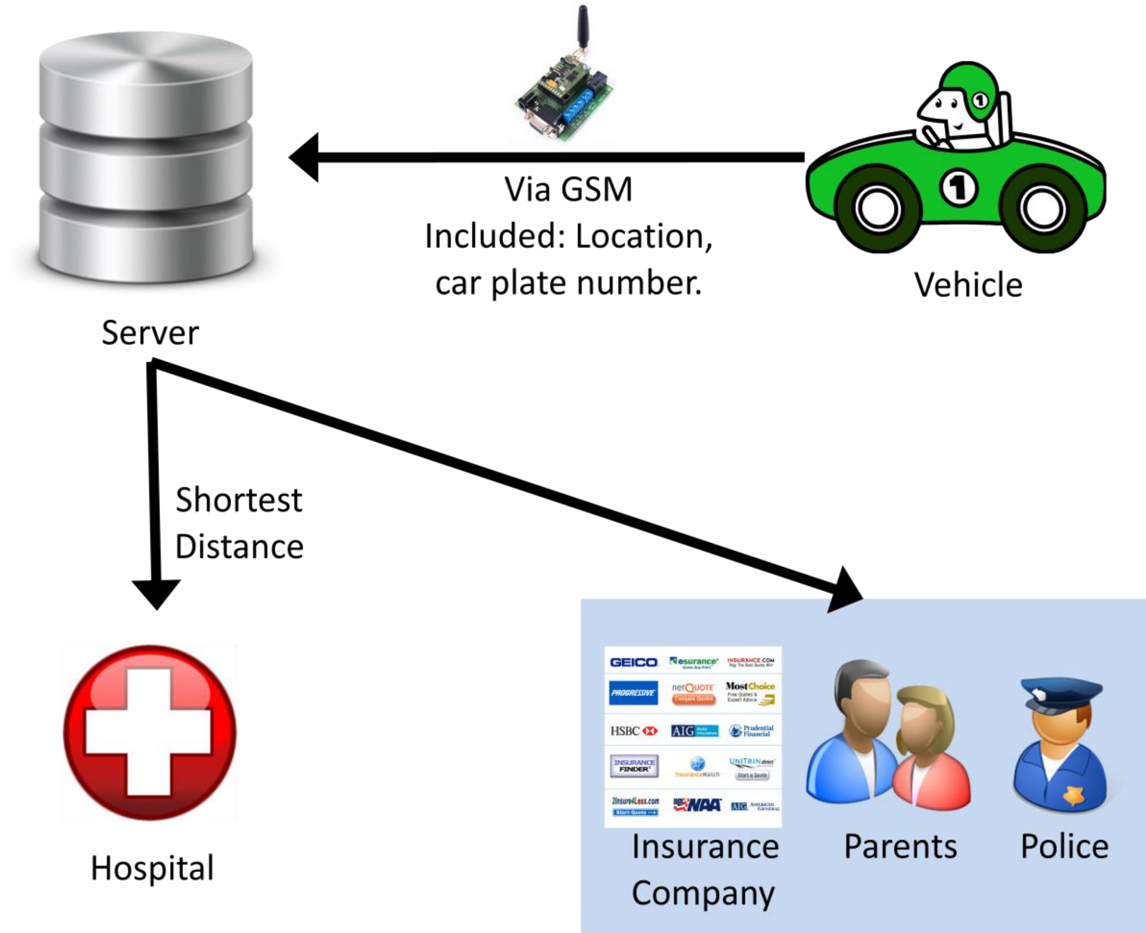


Figure 13: System concept of Automated Accident Location Detection System

The whole system concept of Automated Accident Location Detection System includes 4 main actors: the vehicle with the device is installed, the server to route the message and calculate the shortest distance, the hospital who provides immediate assistance to the victim and the others emergency agents such as insurance company, parents, police and even a fire department.

The first action will be escalated from the vehicle when an event is triggered by the accelerometer which indicates accident has occurred. Then the message will be generated by the device embedded in the vehicle and send to the server via the GSM network (SMS protocol). The information includes the location (coordinate in latitude and longitude), car plate number, time and date of the accident.

Next, the server will receive the information from the device through a short message service (SMS) and the information will be extracted and used for calculation. The calculation will be done using the Google Map API v3 which will find the shortest path from the coordinate of the accident and the nearest hospital. On the other hand, the server will redirect the message to the insurance company, parents, police and fire department too. In the hospital side, they will be provided a website interface to accept or decline the emergency support depending on their current equipment availability.

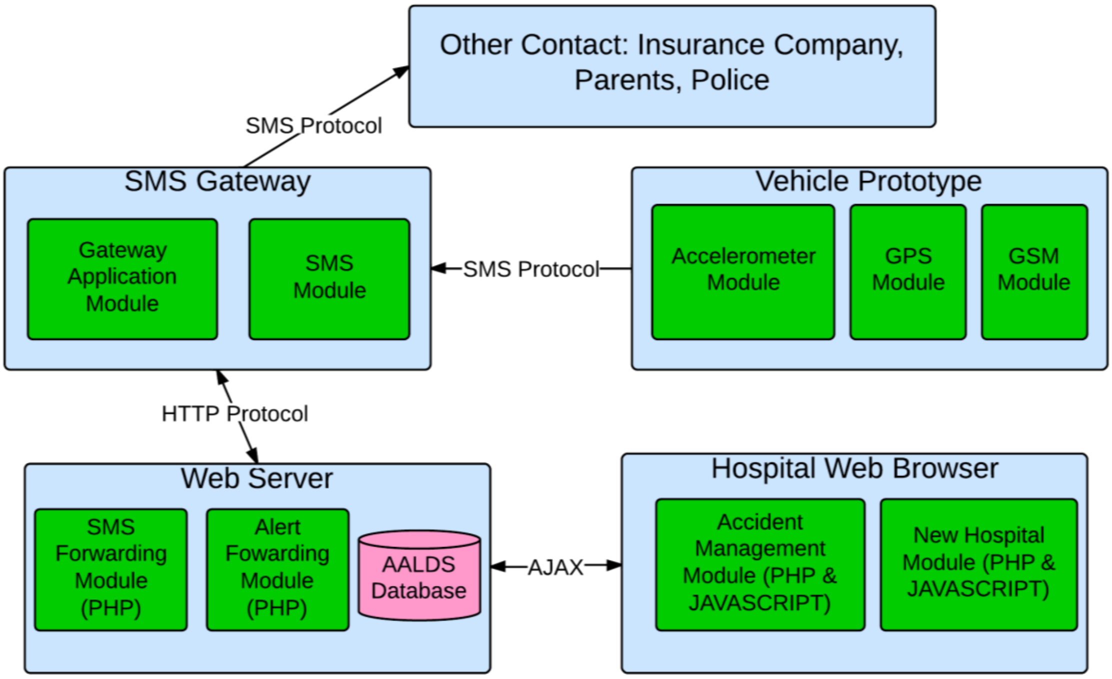


Figure 14: System architecture of Automated Accident Location Detection System

Figure 14 shows the complete system architecture of this system which is the breakdown of system concept in Figure 13. Each of the tiers has its respective module to carry out unique functions.

The vehicle prototype has 3 modules which are accelerometer, GPS and GSM module. The modules in the vehicle prototype represent each of the electronic devices embedded. It communicates with the SMS Gateway through SMS protocol.

The SMS Gateway has 2 modules which are gateway application module and SMS module. It communicates with the web server using duplex HTTP protocol, while it also send alert messages to other contact such as insurance company, parents and police using SMS protocol.

The web server contains 3 modules which are SMS forwarding module, alert forwarding module and a database. It communicates with the hospital web browser using AJAX protocol which dynamically checks the information for latest accident event. This enables asynchronous connection between the hospital web browser and the server.

Lastly, the hospital web browser contains 2 modules which are accident management module and new hospital module. These 2 modules act as the interface to communicate with the database in web server. The 5 groups of modules represent the whole system of this proposed project. Further explanation about the processes in each of the modules will be available in result and discussion chapter.

3.4 Requirement Analysis and Specification

The type of users in this system will be the car owner who installed and purchased the device and system, the administrator of the system, the hospital staff, police, fire department, emergency contact of the user and insurance company.

In this project, the author will be focusing on finishing the connection of the device to the server, the design and code the whole website interface for the use of hospital and administrator. The author will use the best algorithm to calculate the shortest path of the accident location to the hospital for immediate emergency support. The system efficiency and performance test will be done by the author once the system is ready for testing. On the other side of the server, it will redirect the message to the police, fire department and the preferred contact person of the user for notifying them about the accident.

The required functionalities in this system will be the coding for the website to retrieve the information from the short message service (SMS) sent from the device of the car owner and calculate the nearest path to the hospital nearby to redirect the message to them within seconds. An interface for handling the hospital operation is needed for the hospital user to accept or decline the emergency support event. All the information will upload to the server and trigger all the parties who need the real time information for rescuing effort. Therefore, all the operations need a server to be working well. A high speed web server will be purchased for the implementation of this system.

The limitation in this project is mainly on making agreements with the hospital staff in every hospital in Malaysia, as the time constraint is only a semester. Limited hospitals can be contacted at the time given. Therefore, Perak state only will be taken as input for the testing phase later in this project. The further public relation with all the hospital in Malaysia will be handled after FYP1. Moreover, the device embedded in the vehicle is quite fragile due to the limited budget available in Final Year Project. The equipment installed in the system in still not an industrialized product. An extra care is needed for keeping the device in good condition.

3.5 Project Activities

Upon completing this project, author had come out with the initial project planning. As we all know in order to get an effective result we need to spend 50% of the project period for planning. Author always follow this timeline in order to finish this project during the time provided. These activities breakdown, explained and shown as below:

- Initial planning

  In the very beginning of the Final Year Project 1 (FYP1), a list of title is brainstormed with multiple supervisors. The best 3 titles were chosen for FYP1 proposal. All the basic stakeholder and requirement is listed out briefly in the proposal document. Author had filled in the preferred supervisor name in the proposal for the board to make confirmation.
- Planning

  Confirm on the assignment of supervisor by the board of FYP. Multiple meetings with the supervisor will be carried out throughout the project for clarify the problems faced by author. There are several inputs and outputs are shared to always ensure that the project is on the right track. The planning phase also includes the analysis and specification part. An extended proposal is submitted to the supervisor for marking. In the extended proposal, the background of study, problem statement, objective, scope of study, the relevancy of the project, feasibility of the project, the literature review and methodology is included for reviewing by author's supervisor. Then the planning phase continues by setting up the key milestones and Gantt chart to be followed throughout the project timeline. Furthermore, survey is done by distributing several questionnaires to the Malaysian motor vehicle driver (car driver) and interviews a few of the drivers for the feedback and explanation on the current situation. Additional planning on the system efficiency and performance test will be done in Final Year Project 2 (FYP2).

- System Design

  Author will roughly sketch the interface of the website and the whole process flow of the whole system. The system architecture is refined and finalized as the reference of this project. The interface flow, the backend system will be drawn out and coded in the following phase. Detail system architecture will be created in this phase. This phase is repeated at the next iteration with a new target on different part of the system.

- System Prototyping

  Coding is the main activity in this phase. The coding will be based on the process flow, system architecture and the sketches of the design from the previous phase. The system prototyping will start with coding the user interface and testing. Then, it will resume to the implementation part. During the next round, of this phase, the author will only start to code the functionalities of the system according to the requirements stated. The coding will be updated time to time depends on the results of implementation.

- Implementation

  In this phase, the partial product will be tested in a real system environment with a mock up server and input. Debugging is done in this phase and all the errors and flaws will be recorded for further planning and prototyping in the next rapid application development cycle. This phase will connected to the very first phase of this project which is planning phase.

- Complete System

  A complete system will be published if only the prototyping is completed. An incremental software release method will be used to constantly update the system and fix the bugs and errors.

3.6 Key Milestones

Table 4: Key milestone of FYP1 and FYP2

Project Activities	Target Date	Milestone	Deliverables
Initial Planning, Planning, System Analysis & Specification	Week 1-6 (FYP1) Week 1-6 (FYP2)	Determine project scope Identify constraints Perform requirement gathering Perform data mining and research	Proposal Extended proposal
System Design	Week 4-14 (FYP1) Week 1-14 (FYP2)	Create an original architecture design Prototype design	Basic design of the system
System Prototyping	Week 5-14 (FYP1) Week 1-14 (FYP2)	Code Test the functionalities created Develop interface and coding Experiment with different input Set up the functionalities according to the requirement	System interface System functionalities System efficiency and performance testing result
Implementation	Week 6-14 (FYP1) Week 1-14 (FYP2)	Test the interface Test the website	System interface Incremental complete product
Documentation	Week 3-12 (FYP1) Week 1-14 (FYP2)	Document all works done throughout the cycle Integrate the data mining and research	Progress Report Progress Report 2 Proposal defend Dissertation

3.7 Gantt Chart

Table 5: Gantt chart of FYP1

Activities/Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Initial Planning														
Planning, System Analysis & Specification														
System Design														
System Prototyping														
Implementation														
Documentation														

Table 6: Gantt chart of FYP2

Activities/Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Initial Planning														
Planning, System Analysis & Specification														
System Design														
System Prototyping														
Implementation														
Documentation														

4. RESULT AND DISCUSSION

4.1 Prototype

The prototype of the system is divided in to 2 parts which are the website system (interface) and the accident detection device.

Figure 15 shows the interface design of the web interface for administrator use and hospital use. This is the home page of the Automated Accident Location Detection System (AALDS) showing some of the navigation for the web page.

Figure 15: Home page of the AALD System

The navigation bar of AALD system consists of:

- About

  Information about his project will be explained in this page. The visitor can have a better understanding on this project and how to use it.

- New Hospital

This page enables the hospital staff to register their respective hospital information and take part in this system.

- Admin

  An administrator map that shows the pin points of participating hospital and accident location.

- Contacts

  This page shows all the information of the developer and university, just in case any of the visitors is interested to enquire.

- Login

  The login page will provide a login field to select the respective hospital registered in New Hospital page. Then, it will redirect to another page, which will be used by the hospital staff to accept or decline an emergency service request.

Figure 16 shows the new hospital page of AALD system. This page will assist the new hospital registration to join the project.

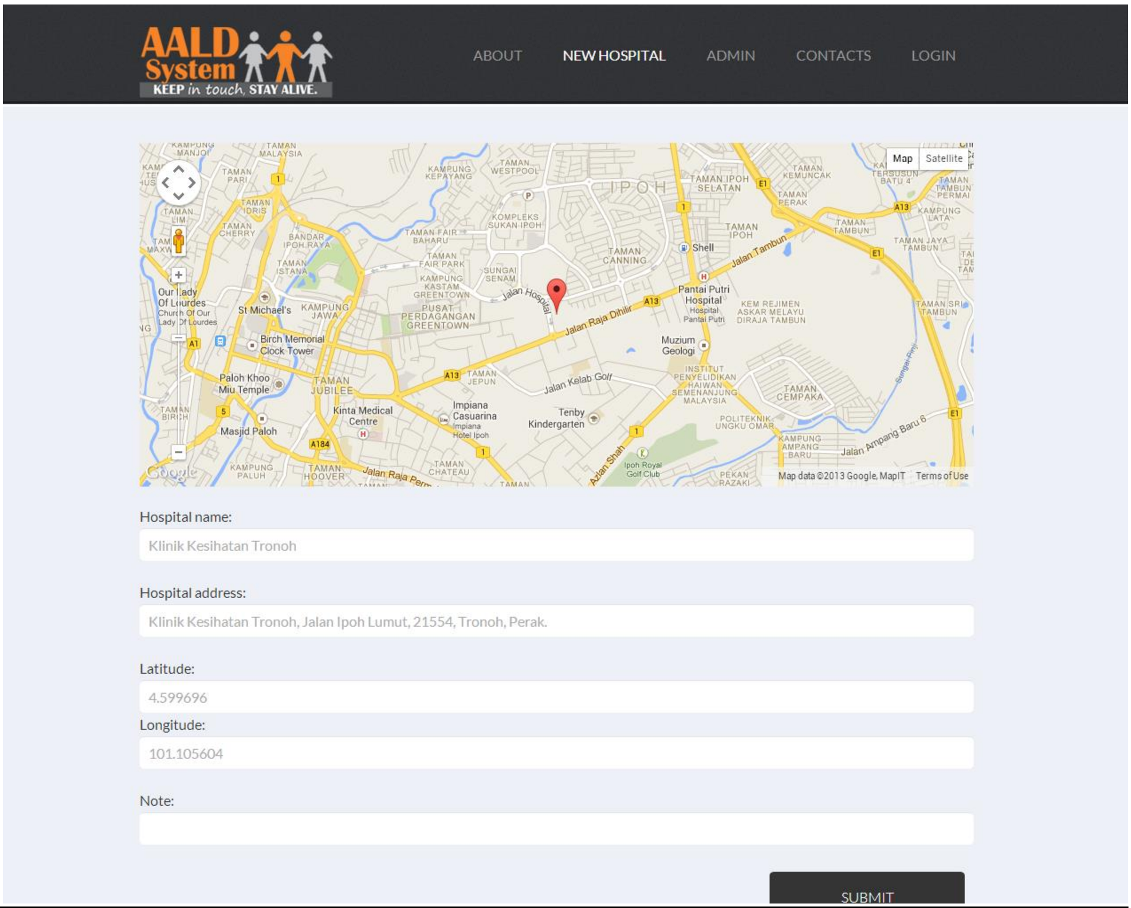


Figure 16: “New hospital” page of the AALD system

There are a few text fields located below the map which is to get the input from the new hospital such as the hospital name, coordinate (latitude and longitude) and address of the hospital. The user is able to drag and drop the red color pin in the middle of the map to select the hospital location. The latitude and longitude will be inserted automatically to the text field. Then, the information will be inserted into the database and wait for the administrator approval before it can be used by the system in the message redirection.

Figure 17 shows the admin page of the AALD system. This map gives the freedom for the user to surf around on the map. All the pin points of the hospital and accident location view are located on the map. User can view the information of the hospital and accident location by clicking on the pin respectively. The hospital icon represents the location of the hospital, while the exclamation mark icon represents the location of the accident. All information in this page is retrieved from the database of AALDS. The coding of the translation made is included in appendix.

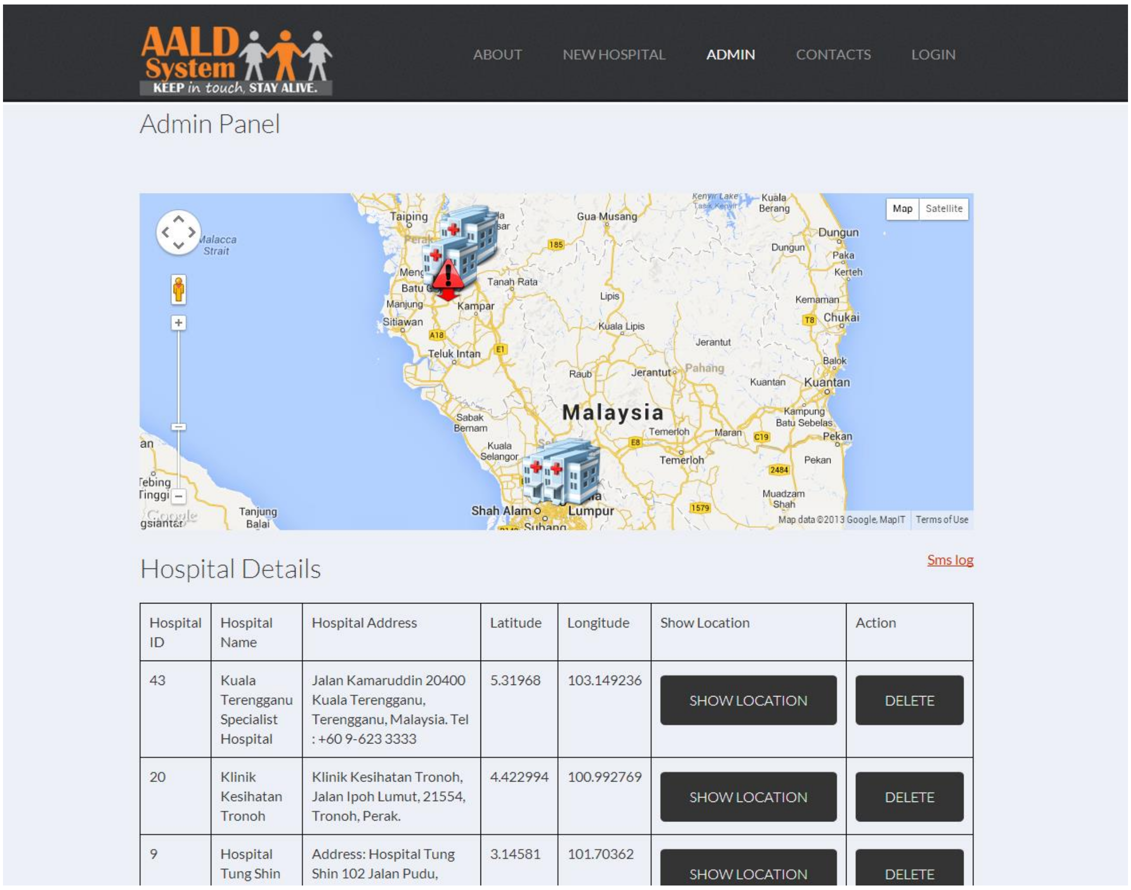
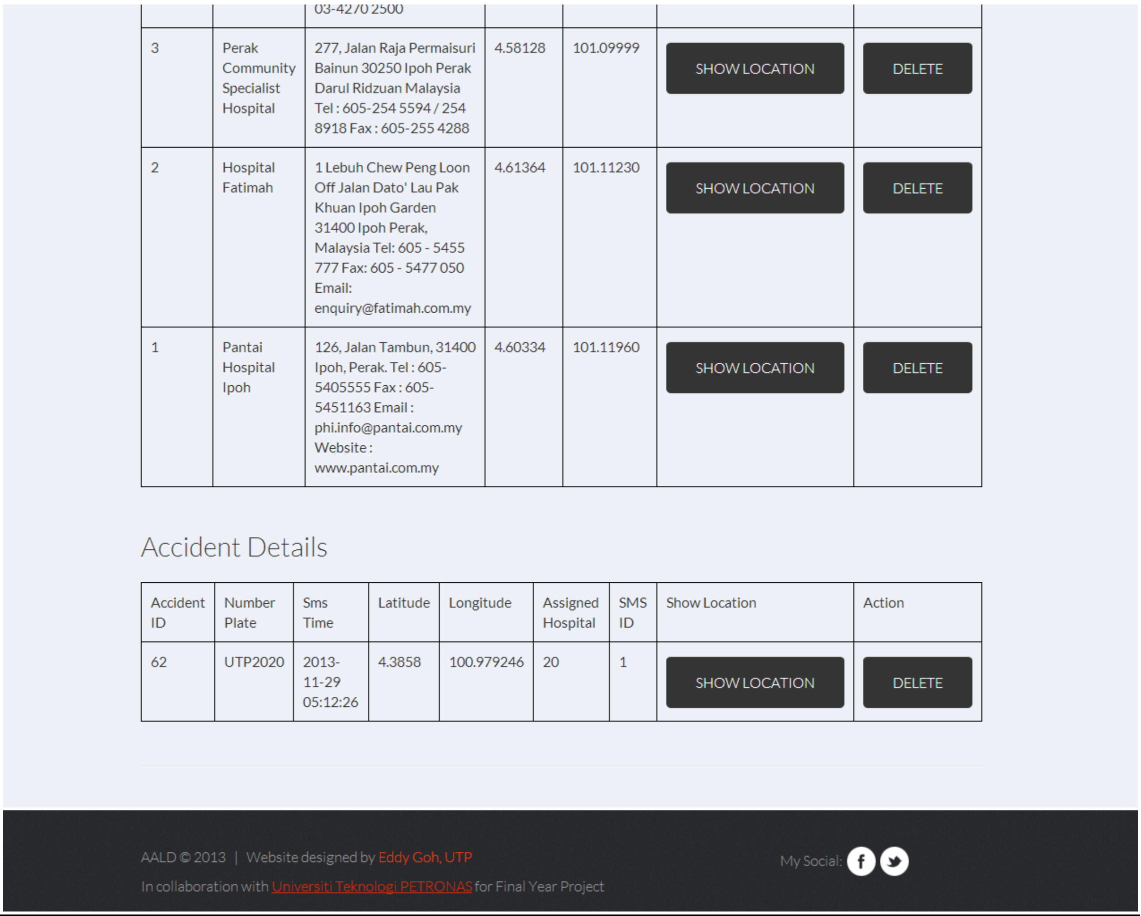


Figure 17: Admin page of the AALD system (Top view) (Administrator use only)

Figure 18 shows the hospital and accident information of each icon labeled in the map. The administrator is able to click on the "SHOW LOCATION" button to pan the map to the respective location of the clicked information. The administrator is also able to delete the hospital and accident from the database by clicking the delete button.



		03-4270 2500				
3	Perak Community Specialist Hospital	277, Jalan Raja Permaisuri Bainun 30250 Ipoh Perak Darul Ridzuan Malaysia Tel : 605-254 5594 / 254 8918 Fax : 605-255 4288	4.58128	101.09999	SHOW LOCATION	DELETE
2	Hospital Fatimah	1 Lebuh Chew Peng Loon Off Jalan Dato' Lau Pak Khuan Ipoh Garden 31400 Ipoh Perak, Malaysia Tel: 605 - 5455 777 Fax: 605 - 5477 050 Email: enquiry@fatimah.com.my	4.61364	101.11230	SHOW LOCATION	DELETE
1	Pantai Hospital Ipoh	126, Jalan Tambun, 31400 Ipoh, Perak. Tel : 605-5405555 Fax : 605-5451163 Email : phi.info@pantai.com.my Website : www.pantai.com.my	4.60334	101.11960	SHOW LOCATION	DELETE

Accident Details

Accident ID	Number Plate	Sms Time	Latitude	Longitude	Assigned Hospital	SMS ID	Show Location	Action
62	UTP2020	2013-11-29 05:12:26	4.3858	100.979246	20	1	SHOW LOCATION	DELETE

Figure 18: Admin page of the AALD system (Bottom view) (Administrator use only)

Figure 19 shows the login page of AALD system for hospital use only. The particular hospital required to login to the server and the customized information for the hospital will be displayed. The user (hospital staff) needs to choose their hospital name from the list. The list of the hospital name is retrieved from the database. If the name of the respective hospital is not on the list, the hospital staff can proceed to the "NEW HOSPITAL" page to register their hospital in order to use this system.

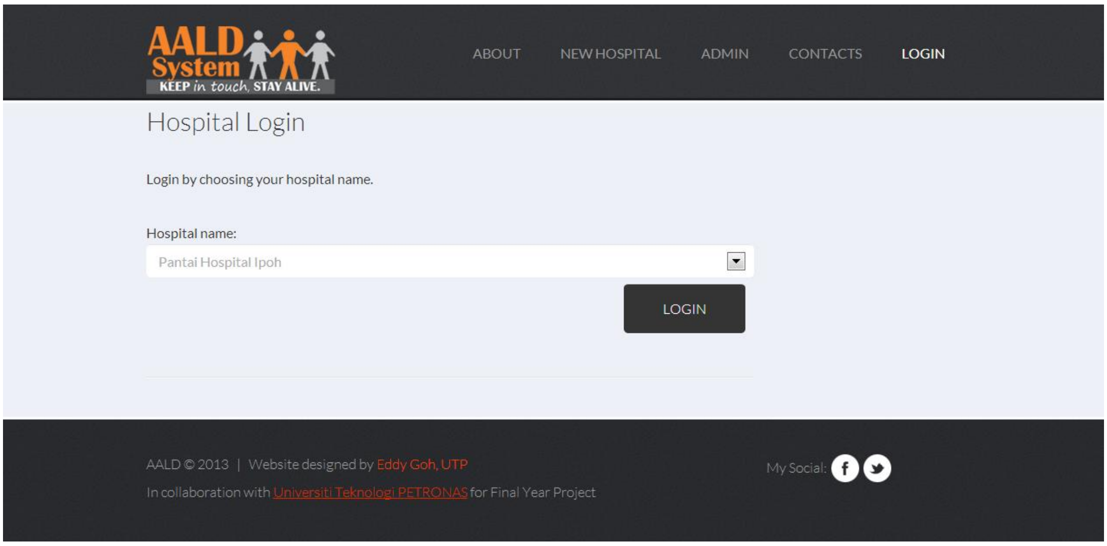


Figure 19: Login page of the AALD system (Hospital use only)

Figure 20 shows the hospital page of the AALD system. The example shows the chosen hospital "Klinik Kesihatan Tronoh". This page listed out the current hospital location and all the accident location based on what the user has accepted. This page has AJAX connection to the database to constantly check for new accident triggered. The hospital staff is able to click on the "SHOW LOCATION" button to pan to map to the selected accident location or mark the accident as done.

Figure 20: Hospital page of the AALD system (Hospital use only)

If there is an accident event triggered, the web page will sound an alarm. The example is shown as Figure 21. The responsible hospital staff is required to accept or decline the emergency response service. If the user clicks the "ACCEPT" button the system will assign the accident to the hospital. If the hospital staff declines the service or not responding to this alert within 20 seconds, the message will be redirect to the second nearest hospital.

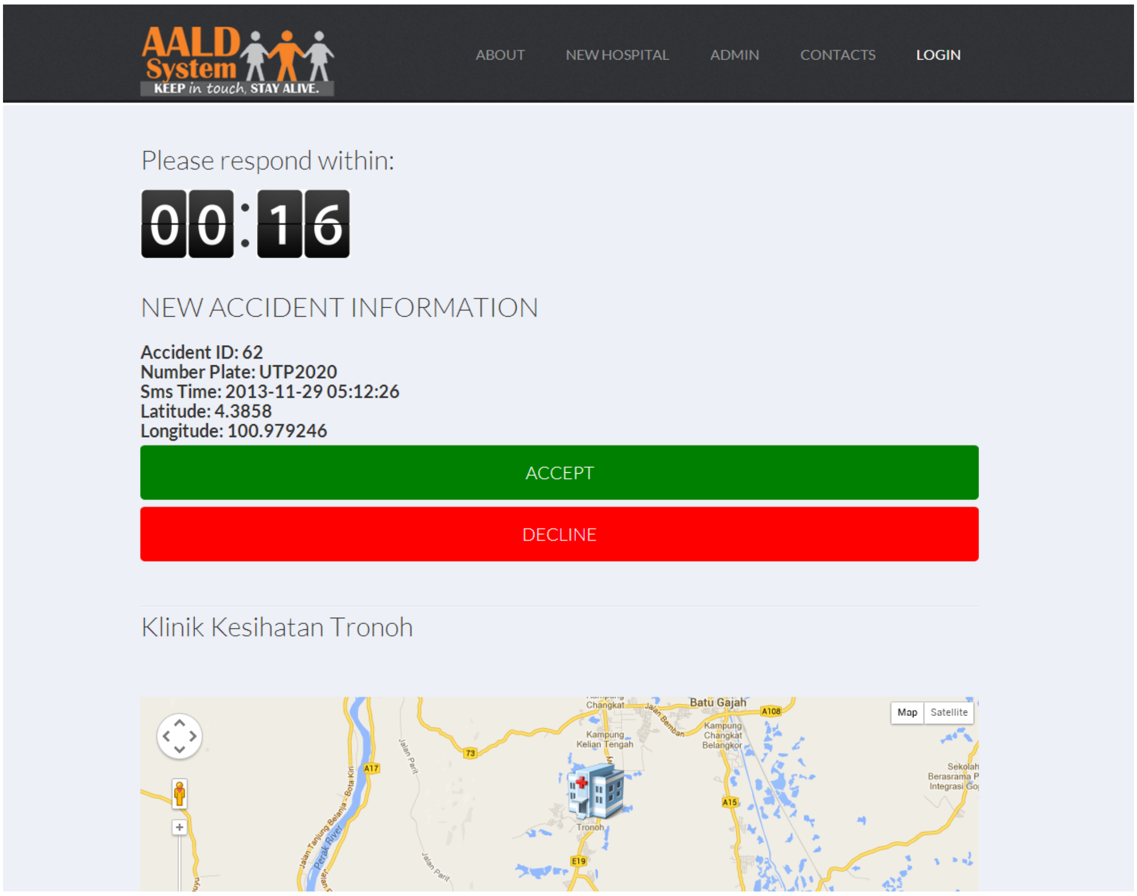


Figure 21: Alert example in hospital page of the AALD system (Hospital use only)

All the map views in this system are using Google Map coded with Google Map API V3 which shows the pin pointing of the hospital location and the accident location.

Figure 22 shows the interface for monitoring the accident detection device installed in the prototype vehicle. The top left side of the interface indicates the X, Y and Z-axis reading from the accelerometer. The recommended accelerometer threshold is set to 2, 2 and 4 after several attempts of experiments. Furthermore, to complete the set up of the accident detection device, the number short message number (SMS) can be include at the text box above the "SMS" label, while the vehicle number plate can be include at the text box above the "vehicle" label. After all the information is set, the device is ready to detect accident event. To connect this interface to the vehicles device, the user needs to click the button "COM5". To close the communication between the computer and the device, click "CLOSE COMM". The button "SET" will save the newest variables from this interface and update the setting to the device, while the button "GET" will retrieve the current setting of the vehicle device. The button "SMS" is only for testing purpose. Clicking it will trigger an accident event to the server. Lastly, the button "LOG" is for logging the current coordinates. This is specially made for testing the hardware status.

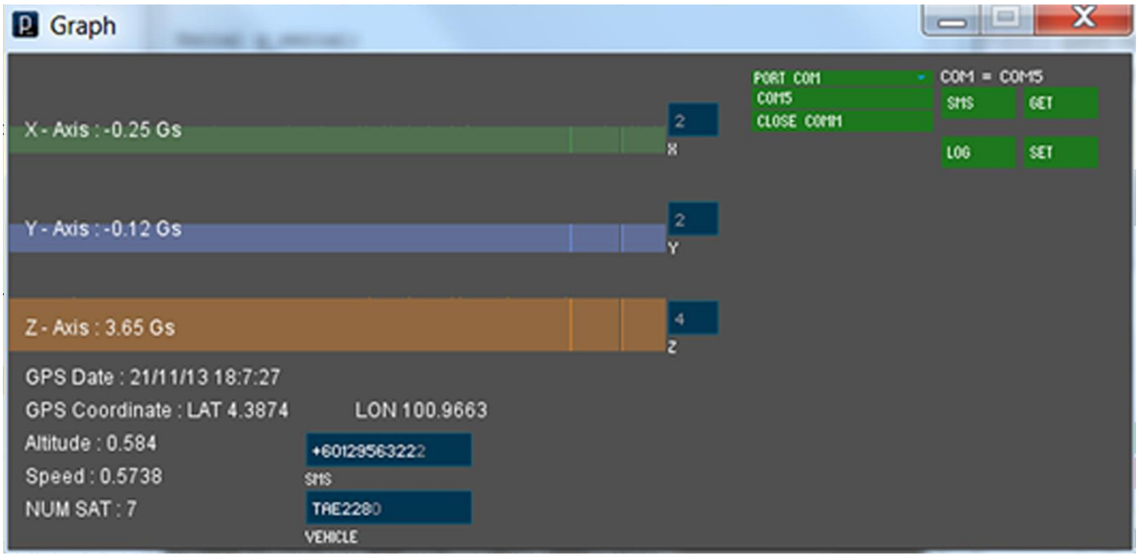


Figure 22: Interface for monitoring the accident detection device embedded in the vehicle

The wireless receiver USB as shown in Figure 23 is used to establish a connection between the laptop and the electronic device attached on the vehicle prototype and setting up the electronic device by using the interface as shown in Figure 22.

Figure 23: Wireless USB receiver for connection between accident detection device in the vehicle and the computer

The vehicle prototype is done by the previous Final Year Project student. The preview of the vehicle prototype is shown in Figure 24. There are 3 electronic modules attached on the structure of the control car, 2 batteries to support the operation of the car engine and the electronic device. The sponge is attached in front of the car to protect the prototype from damage while doing the demo.

Figure 25 shows the preview of the controller of the vehicle prototype. The controller is used to control the movement of the car and to demonstrate an accident by knocking a wall.

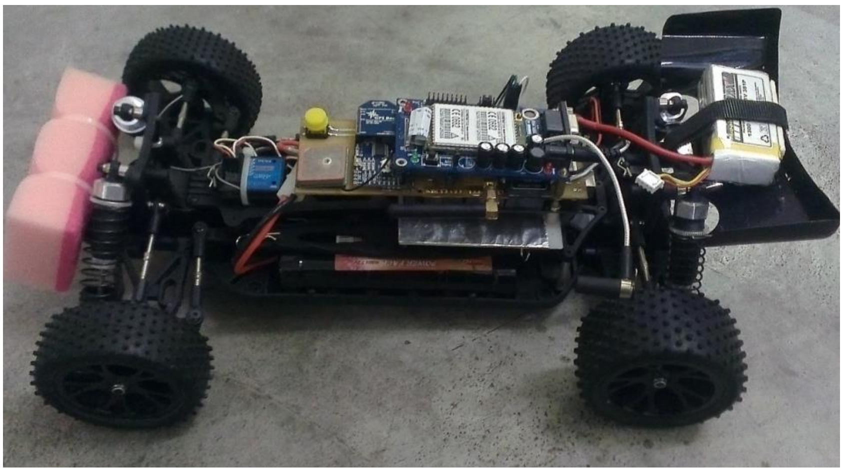


Figure 24: Vehicle prototype

Figure 25: Controller of vehicle prototype

4.2 System Design

Figure 26 shows the system design process flow chart from the beginning of the event starting from the detection activity of the accelerometer in the device.

The device will scan for an accident event until there is an event triggered; the user is required to confirm the accident event by not responding to the system, while the user can cancel the accident event by pressing the button embedded on the accident detector device. Then, the programming of the chip will generate a short message service (SMS) and send it to the server.

In the server side, the flow chart starts with receiving of information from the device. The server will redirect the message to the insurance agents, police and parents of the victims as set. On the other hand, the server will calculate the shortest distance of the accident location and the hospital and redirect the message to the particular hospital for rescuing effort.

If the hospital decline or did not respond to the alert within specific time frame, the alert will be redirected to second nearest hospital for rescuing effort. This process will be repeated until there are one hospital has accepted the alert.

Figure 27 shows the process flow chart of each module in this propose system. The flow chart is divided into its own module for a more structural view of the whole system architecture. The protocols used for communication are labeled at each connecting lines in the figure. For instance, SMS protocol, HTTP protocol and AJAX. The chart is categorized into 3 tiers which are vehicle prototype, SMS gateway and web system.

Automated Accident Location Detection System (Extended)

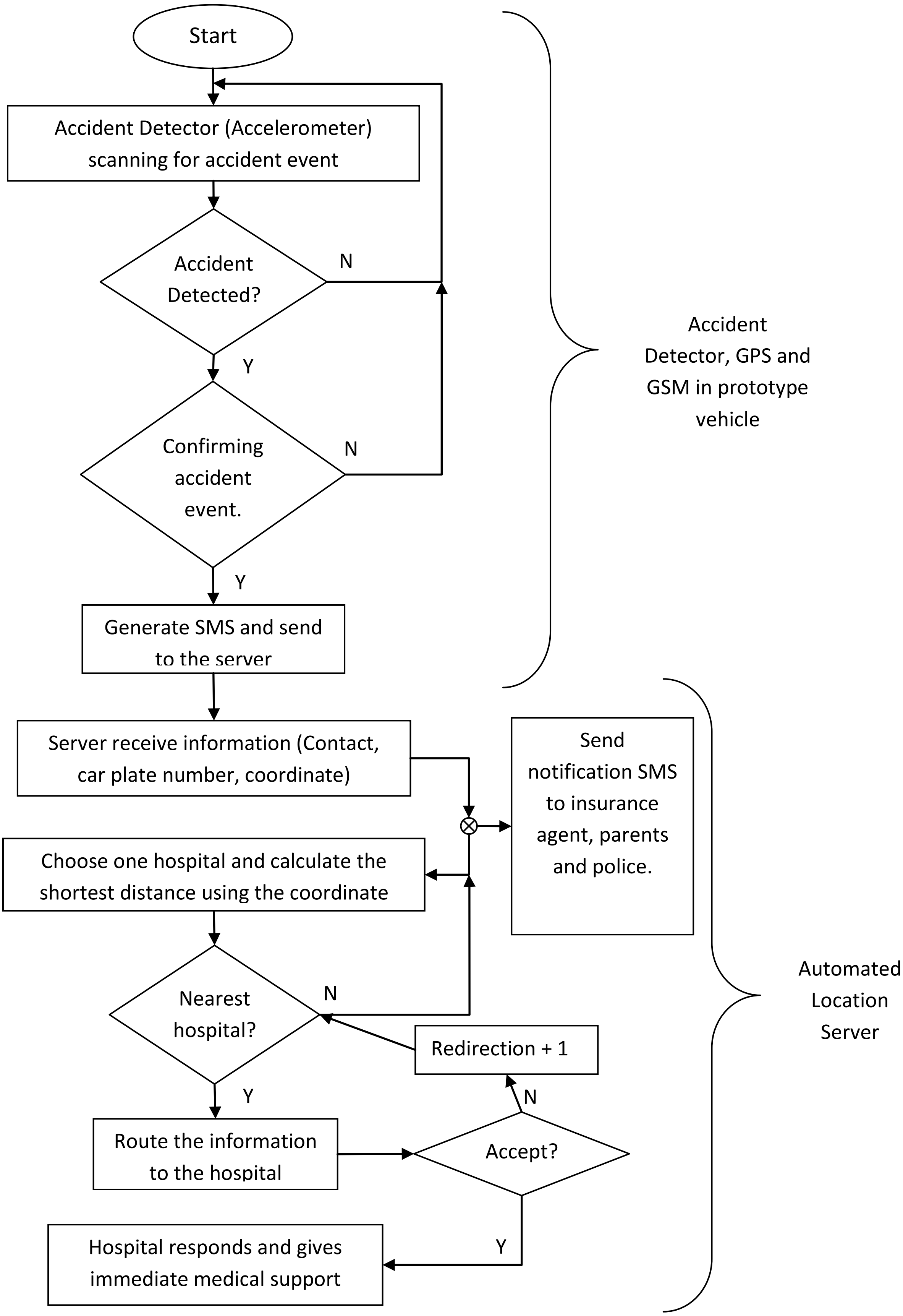


Figure 26: Process flow chart of Automated Accident Location Detection System

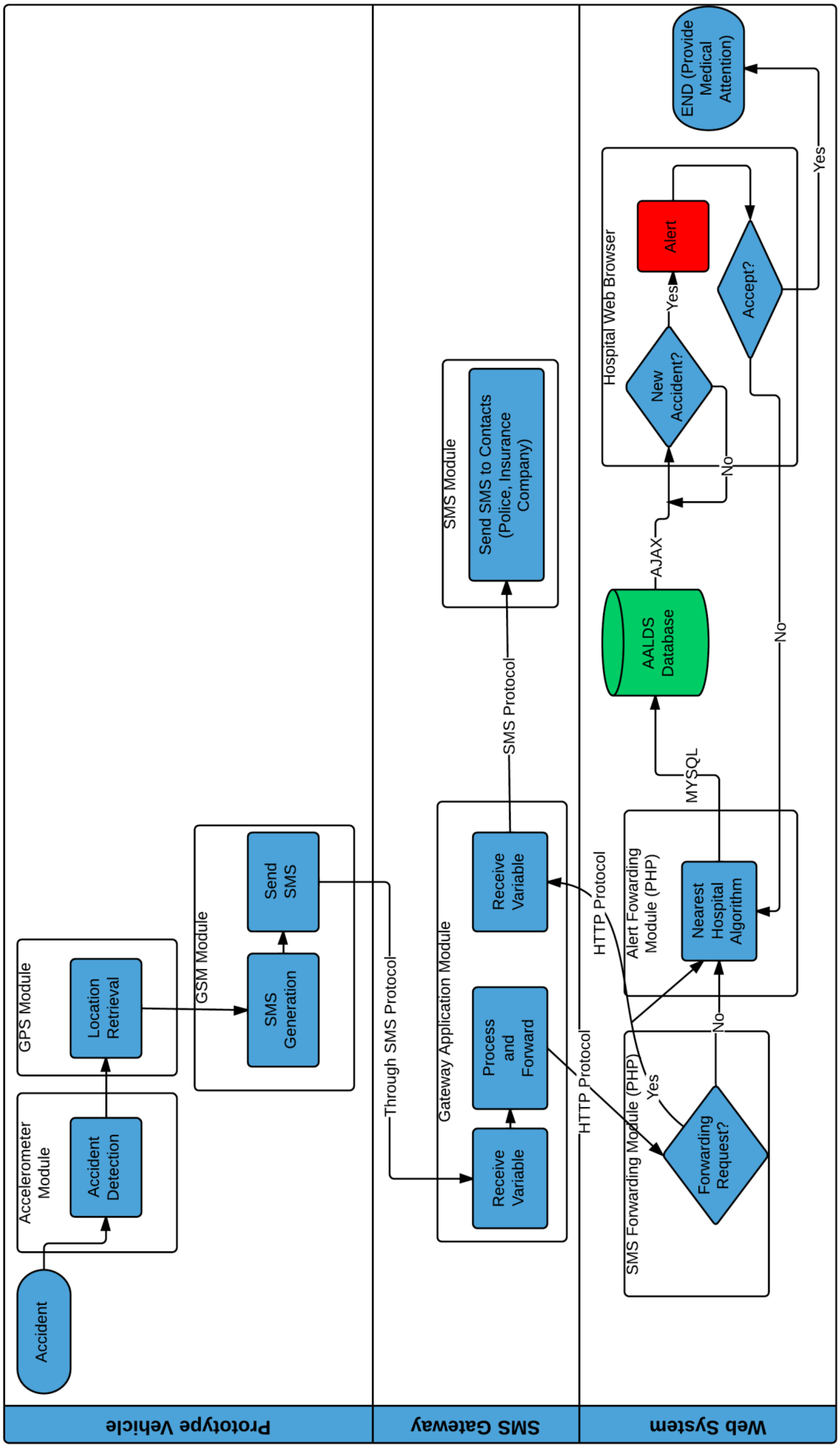


Figure 27: Process flow chart of each module in Automated Accident Location Detection System

Figure 28 shows the website system interface chart. This explained that the website system interface contains 5 pages and several sub pages. There are 2 input pages is set up to obtain the hospital information and the login information. The admin page will display the dots coordinate of all accidents location and hospital participated in this project.

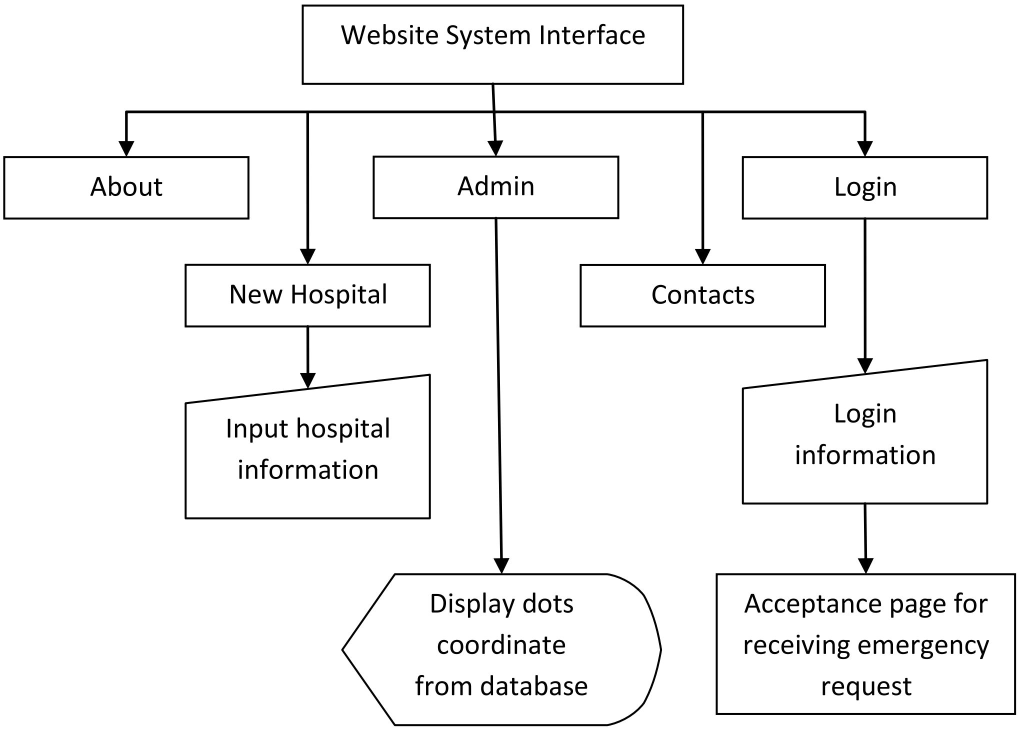


Figure 28: Interface chart of Automated Accident Location Detection website system

4.3 Discussion of Findings and Results

4.3.1 Findings and Results of Quantitative Research

Survey of this project is done by distributing the online questionnaire to 120 respondents. The Google survey platform is used to distribute and collect the results. In section A of the questionnaire, the demographic of the survey are as Figure 29 to Figure 31. Figure 29 shows the pie chart of the respondents according to the age group.

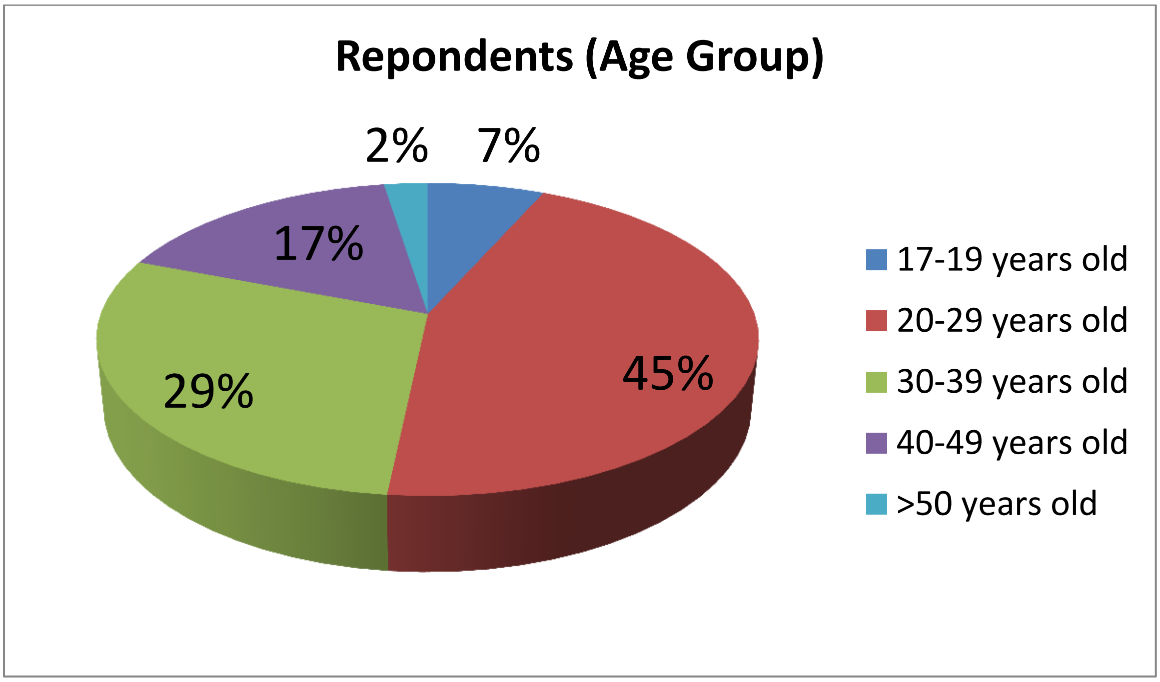


Figure 29: Pie chart showing the percentage of respondents based on the age group

According to the pie chart in Figure 29, the age group of the respondents ranging from 20 to 29 years old recorded the highest percentage which is 45 percent followed by the age group of 30 to 39 years old which is 29 percent. This is due to the technology is used for collecting this information, as most of the elder people do not know how to use a computer. Therefore, they are not able to respond to this questionnaire.

Figure 30 shows the pie chart of the respondents divided by gender.

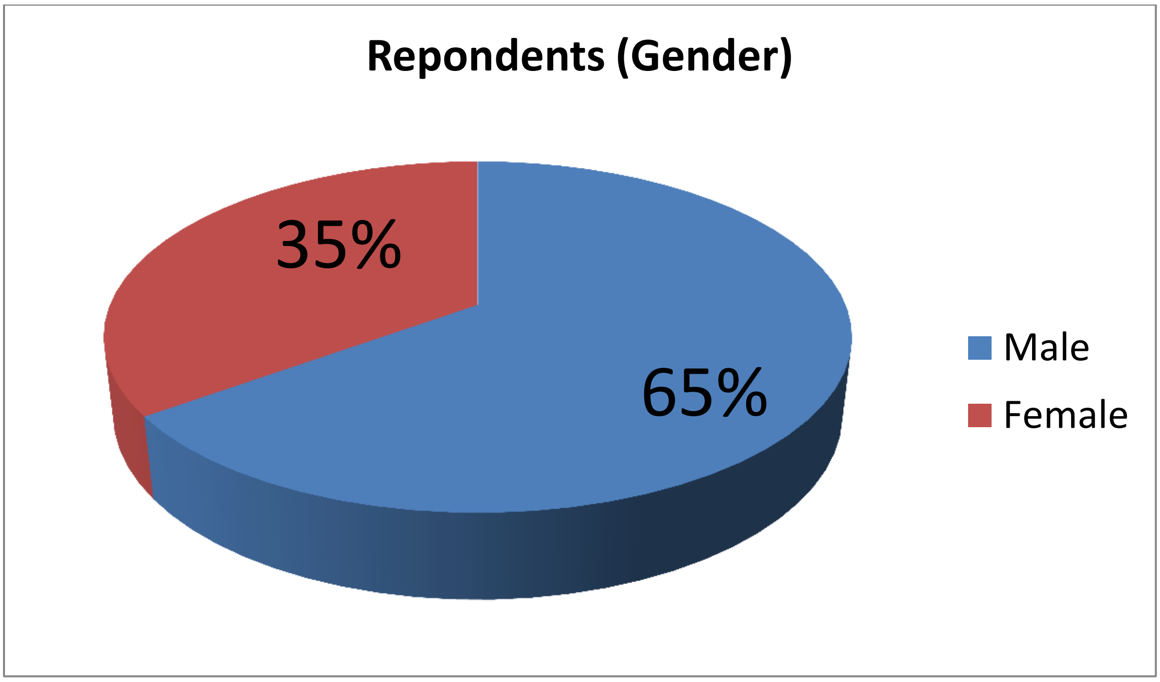


Figure 30: Pie chart showing the percentage of respondents based on gender

By referring to the pie chart in Figure 30, there are 65 percent of the respondents are male and there are 35 percent of them are female. This means that there are more male interested in answering the question related to accident and safety.

The demographic ratio of this survey is quite balance which could lead to a better results in the section B. The Figure 31 shows the pie chart which indicates the percentage of respondents have a driving license.

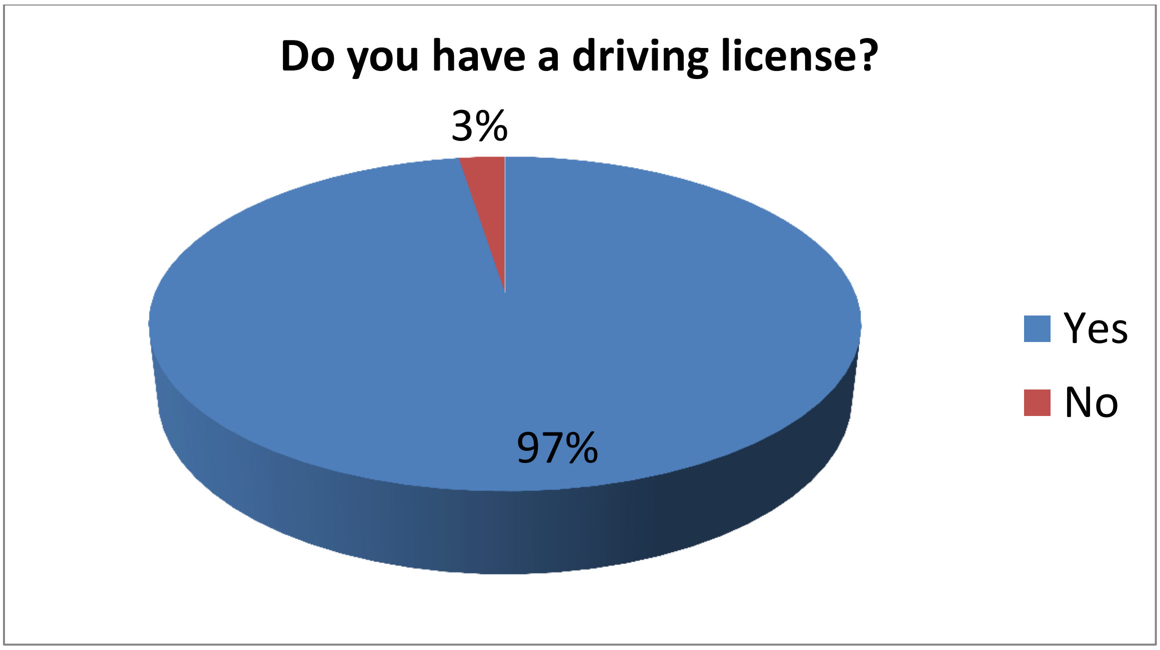


Figure 31: Pie chart showing the percentage of respondents owning a driving license

The pie chart in Figure 31 recorded that 97 percent of respondents have a driving license, while only 3 percent of them do not have a driving license. Therefore, almost all the people in the society tend to have a driving license once they reach the minimum age to get one. This situation will lead to the traffic congestion on the road. Therefore, the more vehicles moving on the road, more potential accident events will be happened.

The bar chart in Figure 32 shows the percentage of the respondents' action when they are involving in an accident.

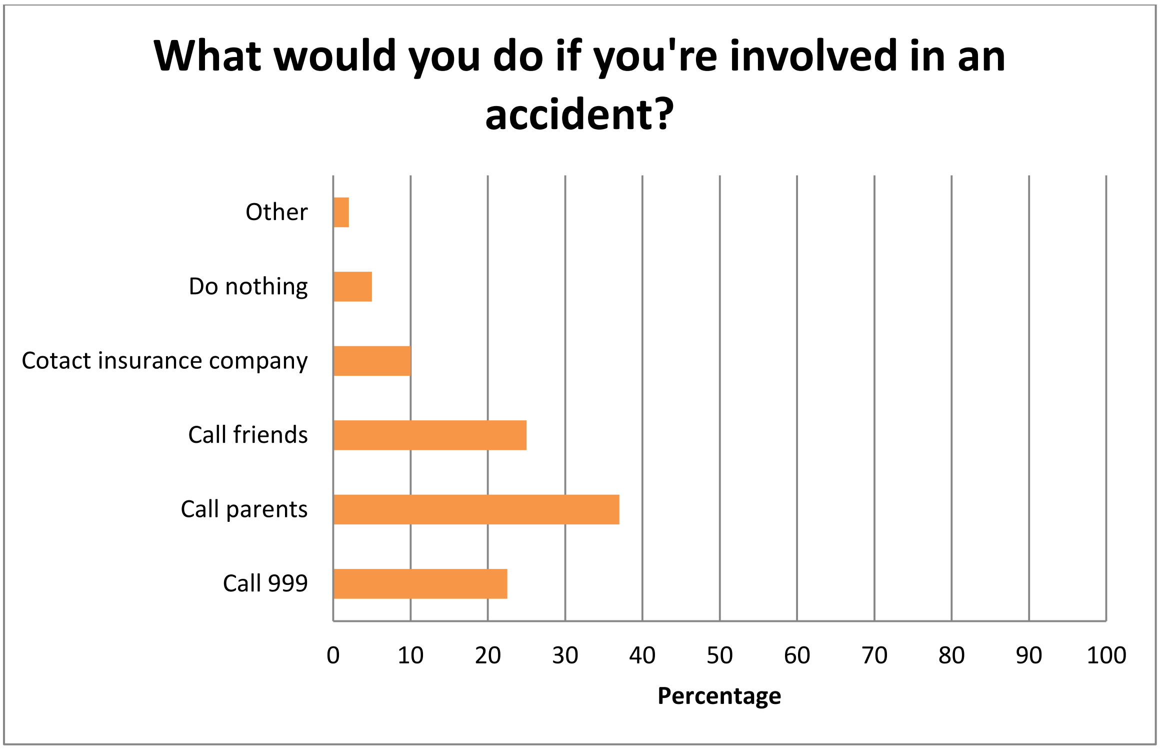


Figure 32: Bar chart showing the percentage of the respondents' action when they are involving in an accident

The bar chart in Figure 32 recorded 37 percent of the respondents action is to call their parents, while there are only 22.5 percent said that they will call the emergency hotline 999 if they involved in an accident. There are 25 percent of them would call their friends followed by contacting the insurance company, doing nothing and other action. This shows that the car driver prefers direct communication with their own parents and friends which can have a faster response time than contacting the emergency operator. The car driver seems to have less confidence on the emergency operator hotline 999. They trust their own parents and friends.

The pie chart in Figure 33 shows the percentage of the respondents who try to call the emergency operator (999) before.

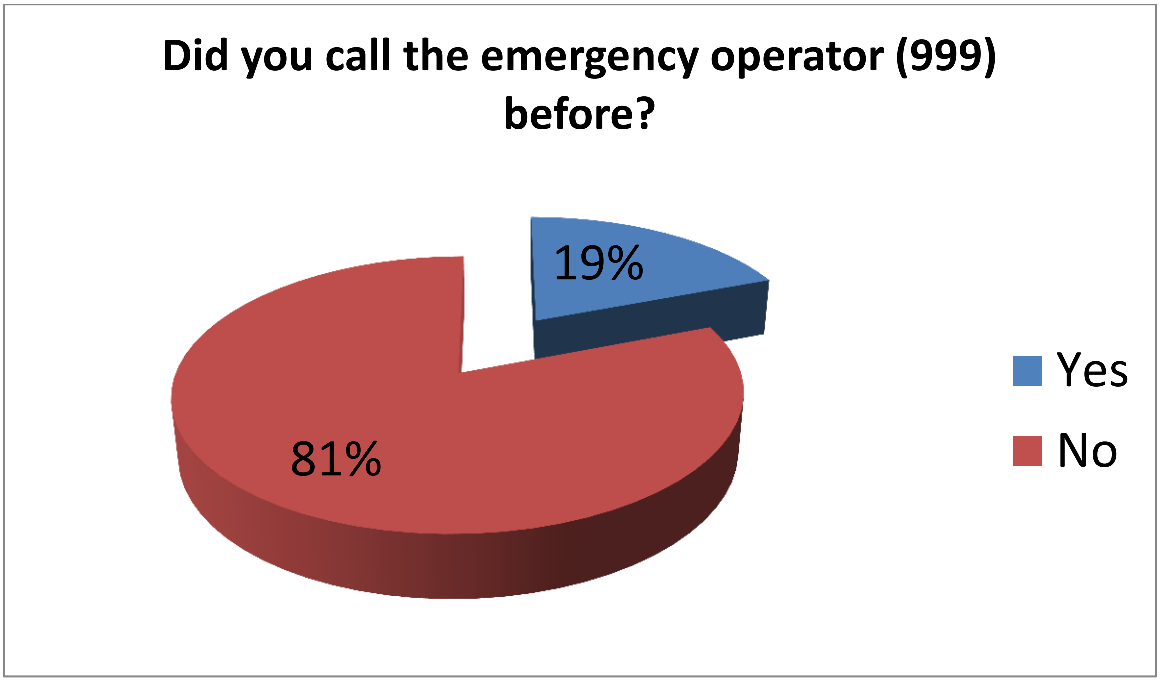


Figure 33: Pie chart showing the percentage of respondents actually called the emergency operator 999 before.

The pie chart in Figure 33 recorded 19.16 percent of them have actually called emergency 999. This contradicts with the previous question which asking what they would do if they are involved in an accident. There are 22.5 percent of them said they will call 999 if involved in an accident but only 19.16 percent have called the emergency hotline. This shows that when they are involved in an accident, they are nervous and panic about what had happened and tend to forget about reporting the accident event to the emergency hotline 999. In this problem, the Automated Accident Location Detection System can help to escalate the accident event to the emergency services without any effort by the victim.

The bar chart in Figure 34 shows the percentage of scaling who think that calling emergency hotline 999 is troublesome. The scaling number 1 means least troublesome, while the scaling number 5 is extremely troublesome to call the emergency hotline 999.

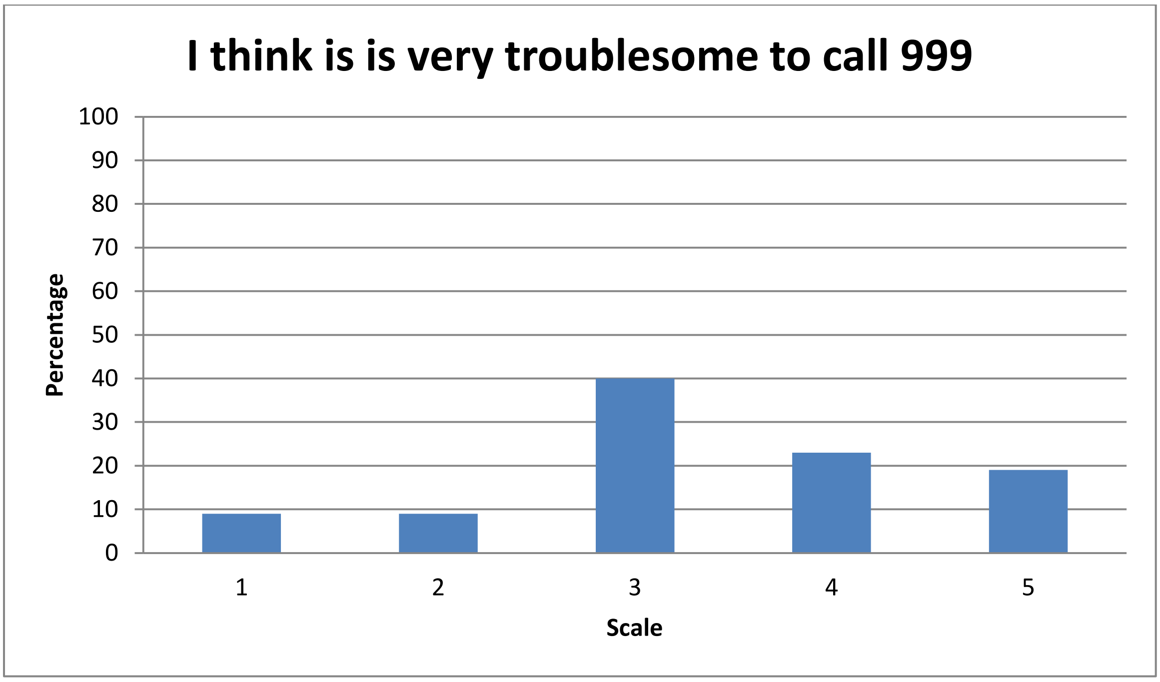


Figure 34: Bar chart showing the scaling of the respondents view about how troublesome it is to call 999

By referring to the bar chart in Figure 34, the percentage of the respondents who voted the scale number of 3 and above recorded the majority of 82 percent. This means that most of them personally felt calling emergency hotline 999 would only bring troubles but not actually helping them. This result proved that the reason of the respondents will call their family and friends are because they think that is very troublesome to call 999.

In the section C, the questions are to rate the experience of the respondents dealing with the operator. The first question is to ask the respondents how long they have takes to make the emergency call start counting at the point the accident occurred.

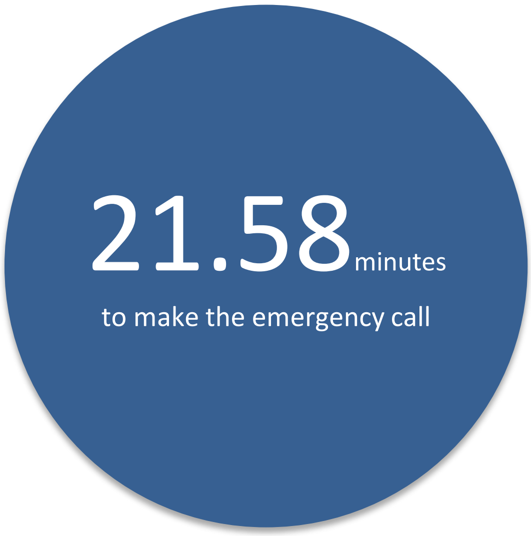


Figure 35: The average time taken for the respondents to make the emergency call

According to Figure 35, the result recorded that the respondents took an average of 21.58 minutes to make the emergency call. The data in this question is calculated and translated to an average number, because it is impossible to show all the length of time taken for each respondent. This shows that there are large amount of time taken to transfer the message from the victims to the emergency operator. The message still need to be redirect to the hospital which will taken another few minutes. This delay the emergency rescue effort which will cause the increasing fatal rate to the victims who involved in an severe accident.

The information circle in Figure 36 shows the average time taken for an emergency operator to pick up the calls.

Figure 36: The average time taken for an emergency operator to pick up the calls

According to Figure 36, the emergency operator took an average of 50 seconds to pick up the emergency calls they received. Comparing to the benchmark they set which is 10 seconds, there are difference of 40 seconds. This shows that another time delay happened while waiting the emergency operator to pick up the call. Therefore, we can conclude that calling the emergency hotline 999 takes a huge amount of time which can cause the victim to lose too much blood and increase the death probability.

The pie chart in Figure 37 shows the percentage of the respondent who have difficulties in reporting the accident location to the emergency operator.

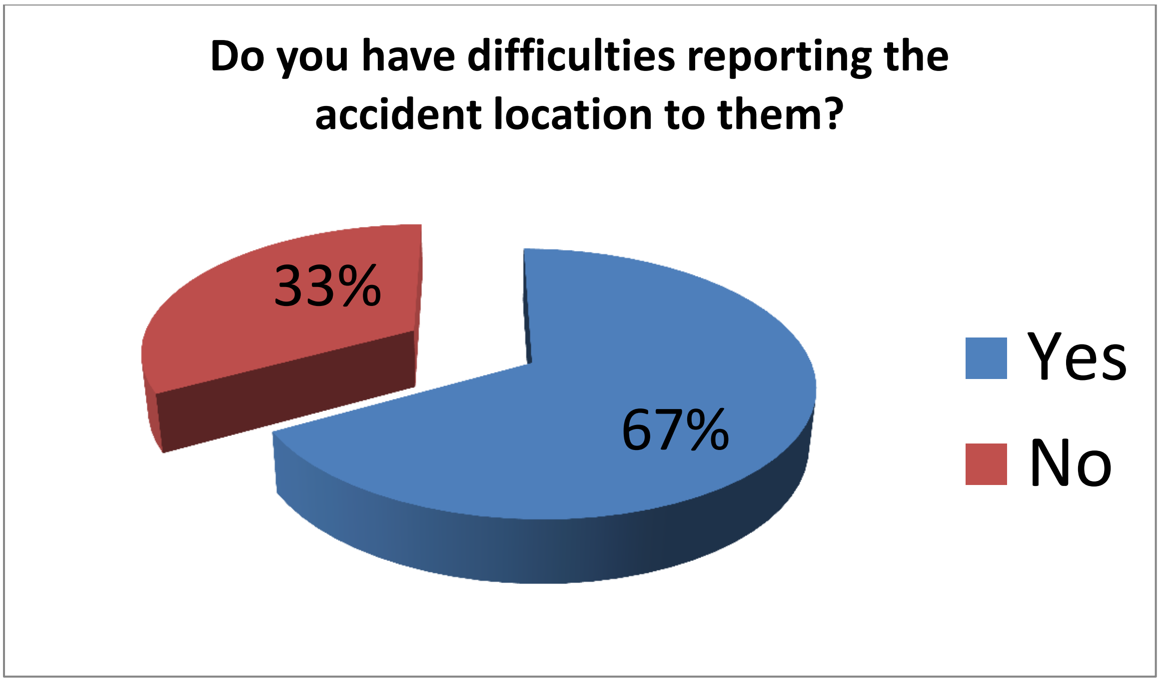


Figure 37: Pie chart showing the percentage of respondents who have difficulties in reporting the accident location

The pie chart in Figure 37 recorded 67 percent of the respondents are having difficulties reporting the accident location to the emergency operator. This shows that there are some verbal communication gap between the caller and the emergency operator. To verbally explain the accident location of the caller, the caller needs to provide specific land mark or street name in order for the emergency operator to locate them. This will takes quite amount of time to complete the explanation to the emergency operator.

The information chart in Figure 38 shows the average time taken for the ambulance or police to reach the accident location.

Figure 38: The average time take for the ambulance or police to reach the accident location

The result shows that it takes an average of 19.46 minutes for the ambulance or police to reach the accident location. This shows that the region and area separation done by the Malaysian Emergency Response Services (MERS 999) is not efficient enough. The hospitals that send the emergency team for rescue effort are located too far away from the accident location. This will slow down the medical attention the hospital can provide to the victims who involved in a severe accident.

The bar chart in Figure 39 shows the rating of the level of efficiency of the current emergency operator in Malaysia.

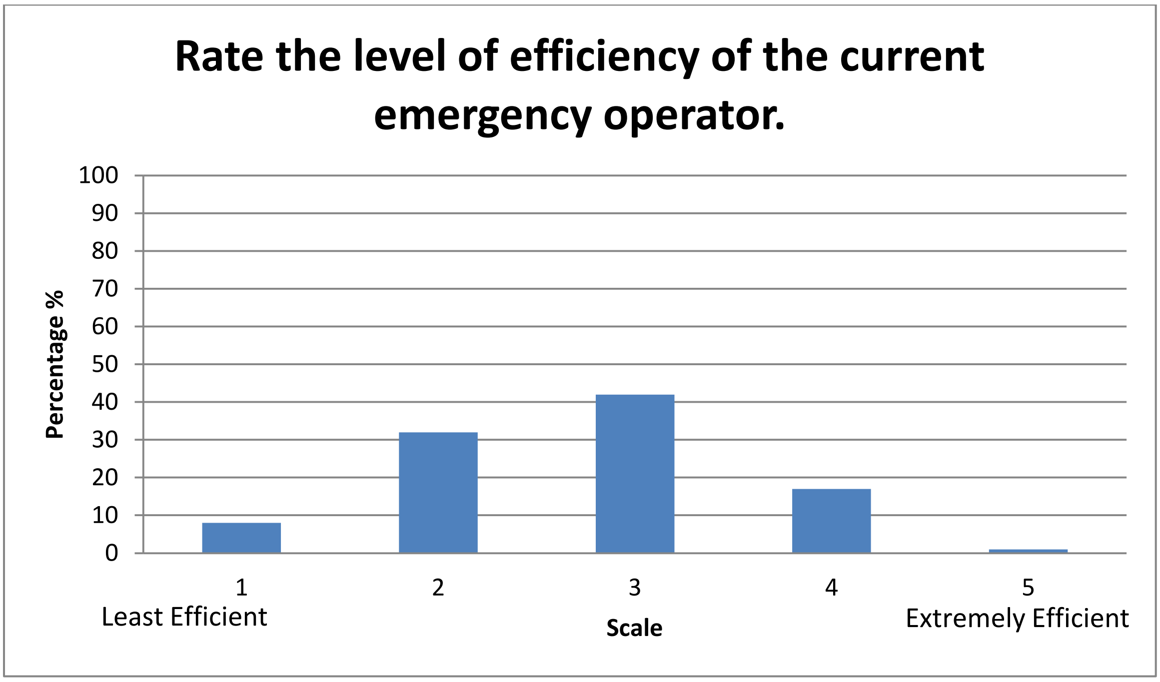


Figure 39: Ratings of the level of efficiency of the current emergency operator in Malaysia

According to the bar chart in Figure 39, about 83 percent of the respondents rate the level of efficiency of the current emergency operator as below average. The average rating of the efficiency level of MERS 999 translated from the bar chart above is 2.66 out of 5. This shows the satisfaction of the citizen is quite low which causes the majority to agree that calling 999 is very troublesome. Based on the qualitative answer given, some of the respondents have commented that the emergency operators are unable to communicate fluently in English. This cause further communication gap between the caller and the emergency operator. The caller are forced to communicate in Malay language which some of them do not speak Malay. This is why they are having hard time reporting the accident to the MERS 999.

The pie chart in Figure 40 shows the safety features the respondents felt that can help to reduce the death rate of an accident.

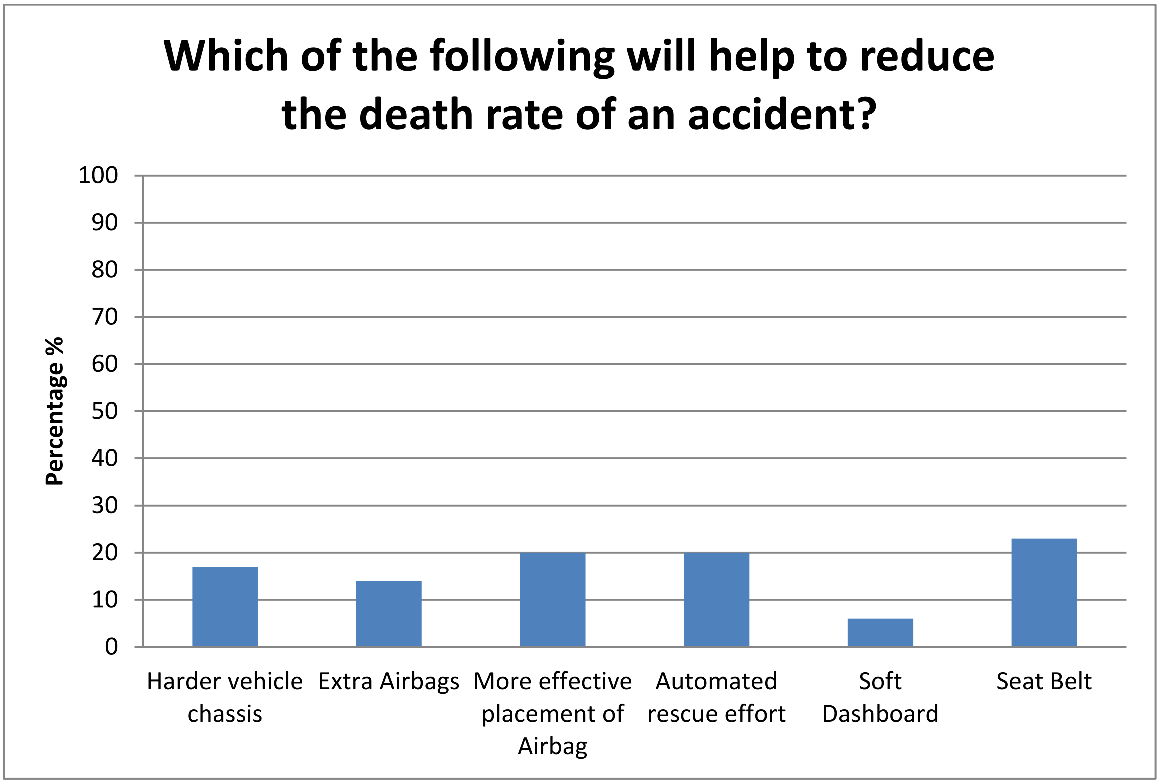


Figure 40: Safety features the respondents felt that can help to reduce the death rate of an accident

According to the bar chart in Figure 40, safety feature seat belt recorded the highest percentage of voting which is 23 percent following by the automated rescue effort and more effective placement of airbag which is 20 percent each, harder vehicle chassis which is 17 percent, extra airbags 14 percent and soft dashboard which is 6 percent.

Most of the respondent voted for all safety features to be installed in their vehicles to ensure their safety on road. This proves that the automated rescue effort is as important as the seat belt and airbags which are already equipped in the vehicle nowadays.

As a conclusion for the survey, the respondents show a supportive result which reflects the literature review well. The implementation of Automated Accident Location Detection System could greatly improve the performance of MERS 999 and provide them maximum usage on their resources available. The respondents will be able to skip all the process of calling the emergency operator by use installing the system in their vehicles. Therefore, all the delays of calling the emergency operator, the time taken for emergency operator to pick up the calls and the difficulties to explain the accident location to the emergency operator can be skipped and avoided. This can speed up the rescuing effort from the hospital and indirectly reduce the fatal rate of accidents.

4.3.2 Findings and Results of Qualitative Research

There is qualitative research done too on this project. The author has done 3 interviews with the Malaysian drivers which are randomly chosen from the pool of the respondents. 15 minutes interviews were done by the author. The summary of the interview responses are listed as below in Table 7 to Table 9.

Table 7: Summary of the first interview

Response	1
Name	Muhammad Muhhiddin bin Iskandar Shah
Age	46
State	Perak
Car Type	Proton Persona
Comments	The current emergency operator is wasting the resources of the government by employing too large number of employees to handle the Malaysian Emergency Reponses Service team. This is because the process flow of the emergency operator is obsoletes and should be replaced with the new one. I have seen a lot of accident events while I am travelling in my vehicle, but I have problem explaining the location of the events. It is because some of the places are new for me. I hope that this system will able to enhance the current system which is obsolete in this era of high technology.

Table 8: Summary of the second interview

Response	2
Name	Terrence Teo Kok Hua
Age	27
State	Perak
Car Type	Myvi 1.3
Comments	I think the government should take this matter seriously as the rescuing effort in Malaysia is a big failure. Some of the victims initially are able to be rescued, but due to the slow medical support, the victims passed away. This Automated Accident Location Detection System could contribute in

	this matter. I have called the MERS 999 once. Based on my experience, the MERS 999 took about 30 seconds to answer the call. Then, I have to report to them what is happening. After they had logging in all the information, they asked for the location. Even though I provided them the exact location of the street, it takes about 15 minutes for the police to reach the destination.

Table 9: Summary of the third interview

Response	3
Name	Tay Zhi Wei
Age	22
State	Melaka
Car Type	Wira 1.5
Comments	The MERS 999 is a basic emergency service in every country. I have never tried the efficiency of this service in other country but Malaysia. As a Malaysian driver observer, the emergency did a good job in helping the accident victims. I always saw ambulances rushing to the accident location for medical attention. However, in year 2012, I was travelling with my friends. During the journey, I saw a person lying in the middle of the highway. I called the MERS 999 because I worried about the person safety. Every explanation went smoothly until the operator asked for my location. I had no idea where is the place I currently was. Then, the operator said that the region is not covered and give me asked me to call another hotline number. They tend to push the responsibility within the region. I think this system will able to solve this problem as the GPS functionality in this system helps to provide exact location to the operator.

The respondents provide feedback on the current emergency operator efficiency and suggest author to improve and modify the process flow of reporting the accident to the authority. They felt that the implementation of MERS 999 is resources wasting and hope that the team can perform better.

Another qualitative research has done on the current MERS 999 team. The author had an interview session with the system integration manager of MERS 999 under Telekom Malaysia. The summary is recorded as Table 10.

Table 10: Summary of interview with system integration manager at Telekom Malaysia

Name	Hafiz Ibrahim
Age	N/A
Position	System Integration Manager at Telekom Malaysia
Comments	The MERS 999 has done a tremendous job in handling the emergency reporting service in Malaysia. I had attended hundreds of conferences and training organized by Telekom Malaysia to train the MERS 999 staff and educates the civilian about this service. According to the statistic, the 999 response center has increasing customer satisfaction index (CSI) from 7.56 (2009) to 8.93 (2011). Although there are increasing complaints from the people which is up to 18 complaints in year 2012, but this cannot be avoid. As there are thousands of emergency events the response center has to handle which will lead to some slight error. I cannot deny that the current process flow is quite long for reporting an emergency event to the authority. I personally have move my focus to use information technology to assist in this matter. Recently, there is an application (SAVEME999) is published to the society. But the usage of this application is only available for the disabled person. I hope the application can expand to be used nationwide. This system could enhance the current emergency reporting service. There are some problems while communicating with the emergency caller such as: unclear voice, silent calls and unknown location. This system could overcome the location factor by using the GPS detection in the device attached to the vehicles.

4.3.3 Findings and Results of Algorithm Accuracy and Speed

For the coding part of the project, the Haversine formula will be chosen, as the Google Map API V3 is using this theory to calculate the shortest distance from the accident location to the hospital. Therefore, by using the application programming interface (API) provided by Google Map, the calculation can be done by using the readily made functions. The implementation part will be referring to the documentation provided by Google Map V3.

Figure 41 shows the PHP coding of inserting 20,000 different pair of coordinates into the hospital table in the database. Latitude and longitude will be created randomly with 4 decimal points. The code below was executed 4 times to get a total of 20,000 different pair of coordinates to be inserted in to the database.

```php
<?php
	include('dbConnect.php');

	//The time now
	date_default_timezone_set('Asia/Kuala_Lumpur'); // CDT
	$timeNow = date('Y-m-d H:i:s');

	$minLa =  -90;
	$maxLa = 90;

	$minLg = -180;
	$maxLg = 180;

	for($i = 0; $i< 5000; $i ++)
	{
		$latitude = mt_rand($minLa*10000, $maxLa*10000) / 10000;
		$longitude = mt_rand($minLg*10000, $maxLg*10000) / 10000;
		$sql = "INSERT INTO hospital (latitude, longitude, deleted, created_at, updated_at)
					VALUES ($latitude, $longitude, 1, '$timeNow', '$timeNow')";
		//echo $sql;
		echo $latitude . ", " . $longitude . "<br/>";
		if (mysqli_connect_errno($con))
		{
			echo "Failed to connect to MySQL: " . mysqli_connect_error();
		}
		else
		{
			mysqli_query($con, $sql);
		}
	}
	echo "FINISH!!!!!!!!!!!!!!!!!!!";
	mysqli_close($con);
?>
```

Figure 41: Coding for inserting dummy coordinates into hospital table in database

The Haversine algorithm performance testing is done using 20,000 different pair of coordinates. The query is executed in MYSQL and used PHPMYADMIN as the interface to get the result. The example of execution is shown as Figure 42.

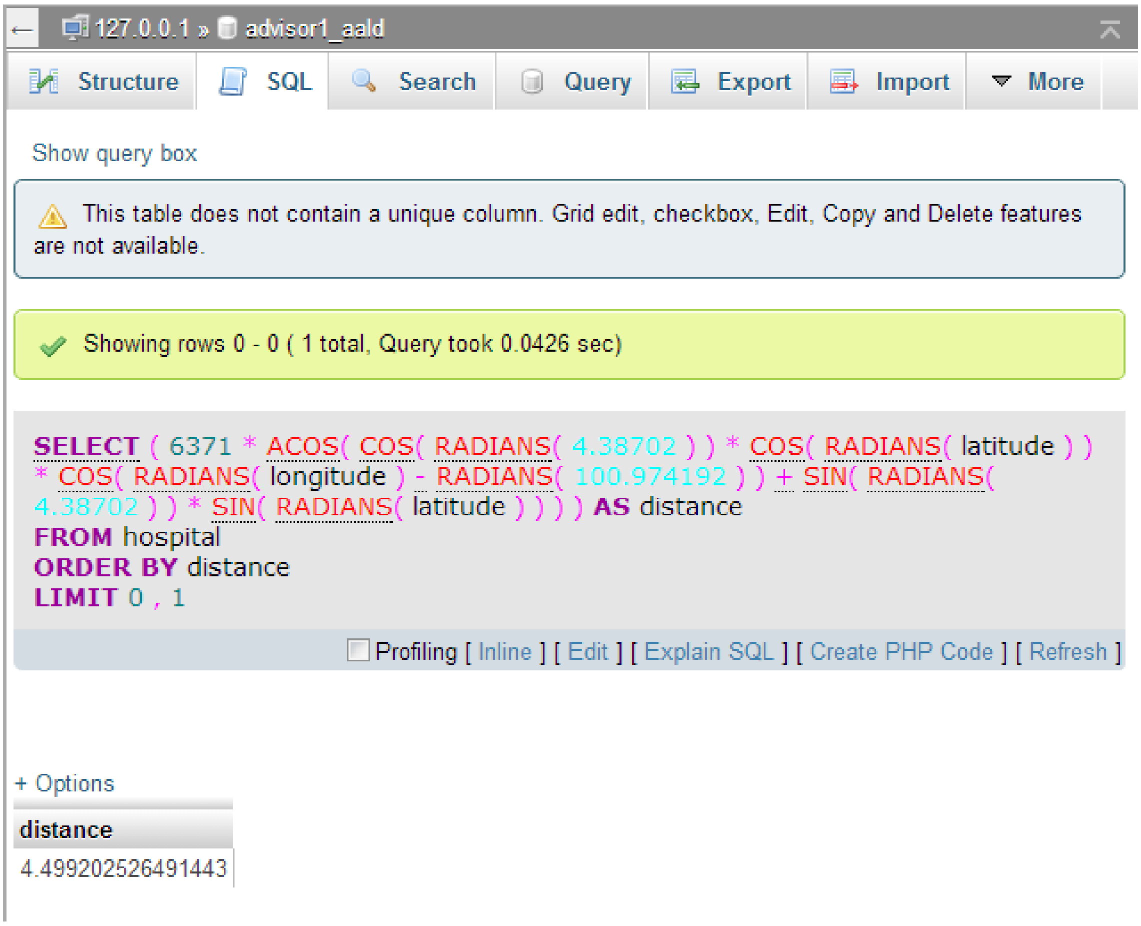


Figure 42: Example of the result using modified Haversine Formula

30 queries are executed using each of the formula and the results are listed in Table 11. The execution time is different in every test because the latitude and longitude input is different in every test. The average time taken for each formula to execute is recorded at the bottom of Table 11.

Table 11: Results of 30 execution of query on modified Haversine Formula vs. Haversine Formula

No. of Test	Modified Haversine Formula (sec)	Haversine Formula (sec)
1	0.0443	4.2868
2	0.0488	4.2908
3	0.0472	4.2832
4	0.0495	4.2854

5	0.0445	4.2901
6	0.0413	4.2872
7	0.0425	4.2868
8	0.0487	4.2901
9	0.0454	4.2900
10	0.0489	4.2871
11	0.0426	4.2858
12	0.0489	4.2898
13	0.0488	4.2874
14	0.0445	4.2908
15	0.0435	4.2912
16	0.0421	4.2868
17	0.0489	4.2954
18	0.0487	4.2848
19	0.0425	4.2877
20	0.0476	4.2897
21	0.0462	4.2758
22	0.0482	4.3544
23	0.0421	4.3152
24	0.0484	4.3101
25	0.0434	4.2987
26	0.0466	4.2891
27	0.0444	4.2904
28	0.0474	4.3121
29	0.0466	4.3284
30	0.0429	4.3014
Average	**0.0458**	**4.2948**

Table 12: Comparison of accuracy and speed between different formulae

Average	Haversine Formula (Modified)	Haversine Formula	Vincenty's Formula
Accuracy	0.3% of the distance	0.3% of the distance	0.5mm (fixed)
Speed (seconds)	0.0458	4.2948	Execution Time Out

Vincenty's Formula has the highest accuracy up to 0.5mm which is fixed regardless the distance of the pair of coordinates, but it has a very long execution time. The execution of Vincenty's Formula in database shows execution time out. This indicates that the formula is too complicated and is taking too long to execute. This is not applicable in such emergency event like accident. Therefore, Haversine Formula is chosen instead for this system. Although the accuracy is only up to 0.3% of the distance between 2 pairs of coordinates, this doesn't affect by the distance between location of the hospital and accident. It is because the furthest distance can be 20km which will result in only 60 meters varies in the query.

The Haversine Formula shows the average speed of 4.2948 seconds. This amount of waiting time is too long for a web query. Therefore, the Haversine Formula is modified to increase the speed of execution.

The modification is done to the original Haversine Formula by adding a limit to the result it searching for. The variables needed to substitute into this formula are:

1. Latitude
2. Longitude
3. Start (Number of start position)
4. End (Number of result)

As a conclusion, the modified Haversine Formula increases the speed of the execution by 99% and result in 0.0458 seconds of average speed with same accuracy as the original Haversine Formula. The formula is stated as the following:

*$sql = "SELECT id, (6371 * acos(cos(radians(" . $latitude . ")) * cos(radians(latitude)) * cos(radians(longitude) - radians(" . $longitude . ")) + sin(radians(" . $latitude . ")) * sin(radians(latitude)))) AS distance FROM hospital ORDER BY distance LIMIT " . $start . ", " . $end . ";'’*

4.3.4 Findings and Results of System Efficiency and Performance Testing

The system efficiency and performance is important for such emergency event, for example, an accident. According to the figure, comparison is made between MERS 999 and this proposed system (AALDS).

The average overall respond time average of MERS 999 is taken from the literature review. As stated in the literature review, the average respond time in Cyberjaya is 8 minutes which is equivalent to 480 seconds. Cyberjaya is selected as “MSAFE” city equipped with thousands of CCTV for reducing the respond time average of MERS 999.

However, the implementation of MSAFE project in Cyberjaya is not cost effective and not feasible for implementation for whole Malaysia. According to The Malay Mail (2013), “the TM had also overcharged the ministry by RM1.57 million for operational management and maintenance of the MERS 999, another area where the A-G said the government should reclaim the funds.” Another area that A-G complained on the promotion and publicity of MERS 999 which cost RM3.19 million by the ministry to TM for nothing. (The Malay Mail, 2013). According to The Malay Mail (2013), “And despite all the extra money paid to TM, the report found that the MERS 999 had performed poorly as a total of 7.65 million calls, or 32.4 per cent of the total calls made to the emergency number were left unanswered.”. This shows that the report provided by MERS 999, Telekom Malaysia is not accurate.

Therefore, the author decided to take only the normal national average respond time instead of the optimum average respond time in “MSAFE” city which is Cyberjaya. As stated in the literature review, the average national respond time is 15 minutes. 15 minutes is equivalent to 900 seconds.

MERS 999 created a new benchmark which is to answer the emergency call within 20 seconds but the current average is only about 30 seconds. According to the quantitative survey, it takes about 50 seconds for the emergency operator to answer the call. Therefore, the average of both worst and best case is 40 seconds. This value is recorded in the accident reporting column.

According to the literature review, the time taken for MERS 999 to asses a call is between 45 to 180 seconds. An average of 112.5 seconds of asses call time is obtained from the average of the best and worst case of assessing a call. 112.5 seconds is recorded in the asses call column.

According to Ministry of Health (2012), there are total of 358 government and private hospital in Malaysia. The area of Malaysia in year 2011 is 330,290km^2. (Ministry of Statistic, 2011). Therefore, there is about one hospital located in every 923km^2. With triangle hypotenuse calculation, the average distance of an accident to a hospital will be approximately 20km. If an ambulance is traveling around 120km/h average, it will be able to reach the destination in about 10 minutes which is equivalent to 600 seconds. The calculation of the approximate average radius of the hospital is recorded as Table 13.

Table 13: Calculation of approximate average radius of a hospital in Malaysia

	Kilometer (KM)
Opposite side (squareroot(923))	~30
Adjacent side (squareroot(923))	~30
Hypotenuse	42.4264
Approximate radius of the hospital	~20

The 900 seconds average overall respond time is divided into several categories as shown in the flow chart of MERS 999. All the value is based on the approximate calculation of different source of data from the government. The value of each fields are recorded as Table 14.

Table 14: The average overall respond time of MERS 999 vs. AALDS

	MERS 999 (average in seconds)	AALDS (average in seconds)
Accident Reporting	40	10
Asses Call (Location)	112.5	0.0458
Create Call Card	15	3
Transfer Caller	60	20
Send Rescue	672.5	500
TOTAL	900	533.0458

The average time taken for an AALDS to operate is based on 30 test runs. For the accident reporting category, the AALDS takes about 10 seconds to send the SMS to the server, while the server takes about 3 seconds (create call card) to create an alert at the respective hospital browser interface. For the asses call, this does not applicable to AALDS, therefore the time for execution of the nearest hospital algorithm based on Haversine formula is used to replace the asses call time. For the transfer call category, it includes the time taken for the person in charge to redirect the message to other hospital or pass the message to the ambulance for instant medical attention.

In a nut shell, AALDS is 366.9542 seconds which is approximately 6 minutes faster than MERS 999. Therefore, this proves that the AALDS is more efficient and has higher performance than MERS 999. This has achieved the objective of this project which is to develop a system that able to speed up the process of reporting.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Relevancy to the Objective

With the recent technology, the authority will be able to provide a better and faster service to the public in term of instant medical attention. The insufficient safety features in a vehicle could be offset by implementing this system to provide medical support for severe accident. Since there are no verbal communications in this system, there are zero communication gaps in reporting any accidents. This system will be able to provide instant medical attention and reduce the fatal rate of accident in Malaysia. The results and discussion proved that the current emergency operator is inefficient and need to be improved. By implementing this system, the system would be able to replace the current emergency operator and provide the most efficient and faster service to the users.

5.2 Suggested Future Works for Continuation

The author has achieved all milestones.

For future works, the suggestion will be including the path finding from the hospital to the accident scene by providing them an application to navigate the ambulance which to avoid the traffic and shorten the travel time. Furthermore, the accident detector device in the vehicle should be made more durable for industrialized purpose.

In a nutshell, all objectives are achieved.

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APPENDICES

APPENDIX 1-1

First page of quantitative survey

Automated Accident Detection Location System

This system detects motor vehicle accident and sends notification to the nearby hospital for instant rescuing effort on the victim.

Installation of this system in the motor vehicles will help the victim by informing the hospital, insurance company and family members on the location of the accident and the car plate number. The hospital will receive the notification and provide immediate medical support.

*Required

Section A (Demographic)

Age *

- (•) 17-19 years old
- ( ) 20-29 years old
- ( ) 30-39 years old
- ( ) 40-49 years old
- ( ) >50 years old

Gender *

- ( ) Male
- ( ) Female

Section B (Preliminary)

Do you have a driving license? *

- ( ) Yes
- ( ) No

Did you call the emergency operator (999) before? *

Any type of accident. (Light, Mild, Severe) Even if you are not involved in the accident.

- ○ Yes
- ○ No

What would you do if you're involved in an accident? *

Even if you have never been involved in an accident.

- ☐ Call 999
- ☐ Call parents
- ☐ Call friends
- ☐ Contact insurance company
- ☐ Do nothing
- ☐ Other: ____

I think it is very troublesome to call 999. *

	1	2	3	4	5	
Least troublesome	○	○	○	○	○	Extremely troublesome

Continue »

APPENDIX 1-2

Second page of quantitative survey

Automated Accident Detection Location System

*Required

Section C (Experience dealing with operator)

How long did it takes to make the call? *

Start counting right after accident occurred.

:
:

How fast did the emergency operator picks up your call? *

:
:

Who did the emergency operator direct your call to? *

Do you have difficulties reporting the accident location to them? *

Yes

No

How fast did the ambulance/police/friends/parents reach the accident location? *

:
:

Rate the level of efficiency of the current emergency operator. *

	1	2	3	4	5	
Least Efficient	○	○	○	○	○	Extremely Efficient

According to the answer you choose above, explain why.

eg: Well trained operator, unable to hear properly, hard to communicate

[ ]

Which of the following will help to reduce the death rate of an accident? *

- [ ] Harder vehicle chassis
- [ ] Extra Airbags
- [ ] More effective placement of Airbag
- [ ] Automated rescue effort
- [ ] Soft Dashboard
- [ ] Seat Belt

« Back | Submit

APPENDIX 2-1

PHP Script to Assign the Accident Event to Nearest Hospital

smsAssignment.php

```
<?php
	include('dbConnect.php');

	//The time now
	date_default_timezone_set('Asia/Kuala_Lumpur'); // CDT
	$timeNow = date('Y-m-d H:i:s');

	$hospitalChosen = ""; //Variable to keep the nearest hospital chosen

	//Save the SMS in server for future reference and redirecting purpose---------------------
START
	//Get auto increment of SMS TABLE
	$sql = "SELECT AUTO_INCREMENT FROM information_schema.TABLES
	WHERE TABLE_NAME =  'sms'
	AND TABLE_SCHEMA =  'advisor1_aald'";
	$result = mysqli_query($con, $sql);
	$row = mysqli_fetch_array($result);
	$smsTable_auto_increment = $row['AUTO_INCREMENT'];

	$sql = "INSERT INTO sms (id, message)
				VALUES ($smsTable_auto_increment, '" .
$_SERVER['QUERY_STRING'] . "')";
	if (!mysqli_query($con, $sql))
	{
		printf("There are some SQL query error:<br/>", mysqli_sqlstate($con));
	}
	//Save the SMS in server for future reference and redirecting purpose---------------------
END

	//Format of message received by server
	$phone= $_SERVER['QUERY_STRING'];

	//$phone=
"%2B60129563222&smscenter=%2B60162999902&text=TAE2234%2C2013-11-
20+00%3A27%3A16%2C4.422998%2C100.982769"; //OLD FORMAT

	$position = strpos($phone, "text=") + 5;
	$phone = substr_replace($phone, '', 0, $position);

	//echo $phone . "<br/>";

	$data = explode( '%23', $phone);
	$data[3] = str_replace('+', ' ', $data[3]);
	$data[3] = str_replace('%3A', ':', $data[3]);
	$data[3] = str_replace('%2F', '-', $data[3]);

	//Process date time to required format by PHPMYADMIN
	$data[3] = strtotime($data[3]);
	$data[3] = date( 'Y-m-d H:i:s', $data[3] );

	echo "<br/>Car plate: " . $data[0];
	echo "<br/>Latitude: " . $data[1];
	echo "<br/>Longitude: " . $data[2];
	echo "<br/>Date time: " . $data[3] . "<br/>";

	$latitude = $data[1];
```

```
		$longitude = $data[2];
		$start = 0;
		$end = 1;
		//$radius = 50000; //this radius is in KM

		//6371 is the conversion for KM
		$sql = "SELECT id, ( 6371 * acos( cos( radians(" . $latitude . ") ) * 
cos( radians( latitude ) ) * cos( radians( longitude ) - radians(" . $longitude . ") ) + sin( radians(" . 
$latitude . ") ) * sin( radians( latitude ) ) ) ) AS distance FROM hospital ORDER BY distance 
LIMIT " . $start . ", " . $end . ";";
		//echo $sql;
		if (mysqli_connect_errno($con))
		{
			echo "Failed to connect to MySQL: " . mysqli_connect_error();
		}
		else
		{
			$result = mysqli_query($con, $sql);
			while($row = mysqli_fetch_array($result))
			{
				$hospitalChosen = $row['id'];
			}
		}

		$sql = "INSERT INTO accident (latitude, longitude, smsReceivedDateTime, 
numberPlate, deleted, created_at, updated_at, hospitalID, smsID)
								VALUES ($latitude, $longitude, ADDTIME('$data[3]','0 8:0:0'), 
'$data[0]', 0, '$timeNow', '$timeNow', $hospitalChosen, $smsTable_auto_increment)";
		echo $sql;
		if (mysqli_connect_errno($con))
		{
			echo "Failed to connect to MySQL: " . mysqli_connect_error();
		}
		else
		{
			mysqli_query($con, $sql);
		}
		mysqli_close($con);
?>
```

APPENDIX 2-2

PHP Script to Support AJAX Accident Checking from Hospital Web Browser

accidentAjaxCheck.php

```
<?php
		//For ajax accident checking
		include('dbConnect.php');
		if(isset($_GET['hospitalID']) && isset($_GET['type']) && $dbConnectivity == TRUE)
		{
			if($_GET['type'] == "check")
			{
				$accidentCount = 0;
				//The time now
				date_default_timezone_set('Asia/Kuala_Lumpur'); // CDT
				$timeNow = date('Y-m-d H:i:s');
				//EXTRACT GET
				$hospitalID = $_GET['hospitalID'];
				$sql = "SELECT COUNT(*) AS accidentCount FROM accident WHERE
hospitalID = $hospitalID AND deleted <> 1;";
				$result = mysqli_query($con, $sql);
				while($row = mysqli_fetch_array($result))
				{
					$accidentCount = $row['accidentCount'];
				}
				print json_encode($accidentCount);
			}
			else if($_GET['type'] == "data")
			{
				$accidentID;
				$latitude;
				$longitude;
				$smsTime;
				$numberPlate;
				$hospitalID = $_GET['hospitalID'];
				$sql = "SELECT * FROM accident WHERE hospitalID = $hospitalID
ORDER BY smsReceivedDateTime DESC LIMIT 0, 1;";
				$result = mysqli_query($con, $sql);
				while($row = mysqli_fetch_array($result))
				{
					$accidentID = $row['id'];
					$latitude = $row['latitude'];
					$longitude = $row['longitude'];
					$smsTime = $row['smsReceivedDateTime'];
					$numberPlate = $row['numberPlate'];
					$smsID = $row['smsID'];
				}
				$data = array(
					"accidentID" => $accidentID,
					"latitude" => $latitude,
					"longitude" => $longitude,
					"smsTime" => $smsTime,
					"numberPlate" => $numberPlate,
					"smsID" => $smsID,
				);
				print json_encode($data);
			}
		}

		mysqli_close($con);
?>
```

APPENDIX 3-1

Code of the Program to Run the Interface of Vehicle Prototype Electronic Settings

```
import processing.serial.*;
import processing.opengl.*;
import controlP5.*; // controlP5 library

Serial g_serial;
ControlP5 controlP5;
Textlabel txtlblWhichcom;
Textfield txtSMS, txtVEHICLE, txtAxisX, txtAxisY, txtAxisZ;
ListBox commListbox;

PFont font;
Button buttonLOG,buttonSMS,buttonGET,buttonSET;

int commListMax, init_com;
int baudRate = 9600;
int LF=10;
int GMT=8;

int[] xAxis;
int[] yAxis;
int[] zAxis;

int currentX = 0;
int currentY = 0;
int currentZ = 0;
//these value were determined by taking readings from a resting position
int oneGSensorValue = 380;
float oneGMillivolt = 200;

int totalReadings = 400;
int readingPos = 0; // the reading position in the array
String SMS ="", VEHICLE ="";

color yellow_ = color(200, 200, 20), green_ = color(30, 120, 30), red_ = color(120, 30, 30),
      grey_ = color(30, 30, 30);

int frame_size_read = 128;
int frame_size_write = 128;
int time1,time2,time3,time4;


String shortifyPortName(String portName, int maxlen)  {
  String shortName = portName;
  if(shortName.startsWith("/dev/")) shortName = shortName.substring(5);
  if(shortName.startsWith("tty.")) shortName = shortName.substring(4); // get rid of leading tty.
part of device name
  if(portName.length()>maxlen) shortName = shortName.substring(0,(maxlen-1)/2) + "~"
+shortName.substring(shortName.length()-(maxlen-(maxlen-1)/2));
  if(shortName.startsWith("cu.")) shortName = "";// only collect the corresponding tty. devices
  return shortName;
}

controlP5.Controller hideLabel(controlP5.Controller c) {
  c.setLabel("");
  c.setLabelVisible(false);
  return c;
}
```

```
void setup(){
  //smooth();
  size(680, 300, OPENGL);
  frameRate(25);

  font = createFont("Arial",12,true);

  controlP5 = new ControlP5(this); // initialize the GUI controls

  txtAxisX = controlP5.addTextfield("X",400,30,30,20);
  txtAxisY = controlP5.addTextfield("Y",400,90,30,20);
  txtAxisZ = controlP5.addTextfield("Z",400,150,30,20);

  txtSMS = controlP5.addTextfield("SMS",180,230,100,20);
  txtVEHICLE = controlP5.addTextfield("Vehicle",180,265,100,20);

  commListbox = controlP5.addListBox("portComList",450,20,110,240); // make a listbox and
populate it with the available comm ports
  commListbox.captionLabel().set("PORT COM");
  commListbox.setColorBackground(red_);
  for(int i=0;i<Serial.list().length;i++) {
    String pn = shortifyPortName(Serial.list()[i], 13);
    if (pn.length() >0 ) commListbox.addItem(pn,i); // addItem(name,value)
    commListMax = i;
  }
  commListbox.addItem("Close Comm",++commListMax); // addItem(name,value)
  // text label for which comm port selected
  txtlblWhichcom = controlP5.addTextlabel("txtlblWhichcom","No Port Selected",565,10); //
textlabel(name,text,x,y)

  buttonLOG = controlP5.addButton("bLOG",1,565,50,45,19); buttonLOG.setLabel("LOG");
buttonLOG.setColorBackground(red_);
  buttonSMS = controlP5.addButton("bSMS",1,565,20,45,19); buttonSMS.setLabel("SMS");
buttonSMS.setColorBackground(red_);
  buttonGET = controlP5.addButton("bGET",1,615,20,45,19); buttonGET.setLabel("GET");
buttonGET.setColorBackground(red_);
  buttonSET = controlP5.addButton("bSET",1,615,50,45,19); buttonSET.setLabel("SET");
buttonSET.setColorBackground(red_);

  xAxis = new int[totalReadings];
  yAxis = new int[totalReadings];
  zAxis = new int[totalReadings];

  for (int i=0; i < totalReadings; i++){
    xAxis[i] = oneGSensorValue;
    yAxis[i] = oneGSensorValue;
    zAxis[i] = oneGSensorValue;
  }


}

void draw()
{

  background(80);
  drawGraph(xAxis, 60, color(#519050), "X - Axis");
  drawGraph(yAxis, 120, color(#708CDE), "Y - Axis");
  drawGraph(zAxis, 180, color(#D38031), "Z - Axis");
  //draw3d(currentX, currentY, currentZ);

  fill(#FFFFFF);
```

```
 text("GPS Date : " + GPS_date/10000 + "/" + (GPS_date/100)%100 + "/" + GPS_date%100 + "
" + GPS_time/1000000+ ":" + (GPS_time / 10000) % 100 + ":" + (GPS_time / 100) % 100,10,
200);
 text("GPS Coordinate : LAT " + GPS_coord[0],10, 220); text("LON " + GPS_coord[1] ,210,
220);

 text("Altitude : " + GPS_altitude,10, 240);
 text("Speed : " + GPS_speed,10, 260);
 text("NUM SAT : " + GPS_numSat,10, 280);


 time1=millis();

 if (init_com==1 && (time1-time2)>100 ) {
   time2=time1;

   g_serial.write(MSP_HEADER);
   g_serial.write(MSP_STATUS);
   g_serial.write(LF);
 }

}

void drawGraph(int[] arrToDraw, int yPos, color graphColor, String name){
 int arrLength = arrToDraw.length;
 stroke(graphColor);
 for (int x=0; x<arrLength - 1; x++) {
   float normalizedLine = norm(arrToDraw[x], 200.0, 600.0);
   float lineHeight = map(normalizedLine, 0.0, 2.0, 0.00, 80.0);
   line(x, yPos, x, yPos - int(lineHeight));

 }
 pushStyle();
 //smallFont();
 stroke(#FFFFFF);
 fill(#FFFFFF);
 String gString = nfc(gFromSensorValue(arrToDraw[arrLength - 2]), 2);
 text(name + " : " + gString + " Gs", 10, yPos - 10);
 popStyle();

}

void draw3d(int currentX, int currentY, int currentZ){
 float normalizedX = norm(currentX, 0.0, 700.0);
 float normalizedY = norm(currentY, 0.0, 700.0);
 float normalizedZ = norm(currentZ, 0.0, 700.0);
 float finalZ = map(normalizedZ, 0.0, 1.0, 150.00, 0.0);
 float finalY = map(normalizedY, 0.0, 1.0, -3.5, 3.5);
 float finalX = map(normalizedX, 0.0, 1.0, -3.5, 3.5);

 pushMatrix();
 ambientLight(102, 102, 102);
 lightSpecular(204, 204, 204);
 directionalLight(102, 102, 102, -1, -1, -1);
 shininess(1.0);
 translate(500, finalZ);
 rotateY(finalY + 1.0);
 rotateZ(finalX);
 fill(#E2E8D5);
 noStroke();
 fill(#B76F6F);
 float heightWidth = finalX * 1.8;
```

```
  box(65, 65, 50);
  popMatrix();
}


/*
This little method creates a running tally of all the incoming sensor readings
and then, when it reaches the end of the array, it pops the first one of the beginning
and inserts a new value in at the end...thus keeping a running tally of the last 400
readings (it can be for any length array, that's just what it's set to for this project).
This works a lot like an RRD graph where my inspiration came from.
*/
int[] insertValueIntoArray(int[] targetArray, int val, int pos, int maxLength){
   if(pos > (maxLength-1)){
     // if the pos == maxSize, shift the array to retain the original value
     int[] returnArray = subset(targetArray, 1, maxLength-1);
     returnArray = expand(returnArray, maxLength);
     returnArray[maxLength-2] = val;
     return returnArray;
   }else{
     targetArray[pos] = val;
     return targetArray;
   }
}

/*
This conversion will vary from project to project
and if you're project is relying on battery power
the reading may need to be adjusted to give you true
one G as your battery power decreases.  All of this is due to
the output of the X,Y, and Z sensors and their coorelation to the incoming voltage at VCC
Check out the specs for the ADXL335 (part of the break out board from Sparkfun.com) here:
http://www.analog.com/en/sensors/inertial-sensors/adxl335/products/product.html
*/
float gFromSensorValue(int sensorValue){
  //convert analog value into millivolts
  float mvValue = (sensorValue-oneGSensorValue) * 4.9;
  return mvValue/oneGMillivolt;
}



// initialize the serial port selected in the listBox
void InitSerial(float portValue) {
  if (portValue < commListMax) {
    String portPos = Serial.list()[int(portValue)];
    txtlblWhichcom.setValue("COM = " + shortifyPortName(portPos, 8));
    g_serial = new Serial(this, portPos, 38400);
    init_com=1;

buttonLOG.setColorBackground(green_);buttonSMS.setColorBackground(green_);buttonGET.setColorBackground(green_);buttonSET.setColorBackground(green_);commListbox.setColorBackground(green_);
    g_serial.buffer(frame_size_read);
    g_serial.bufferUntil(LF);
  } else {
    txtlblWhichcom.setValue("Comm Closed");
    init_com=0;

buttonLOG.setColorBackground(red_);buttonSMS.setColorBackground(red_);buttonGET.setColorBackground(red_);buttonSET.setColorBackground(red_);commListbox.setColorBackground(red_);
```

```
    init_com=0;
    g_serial.stop();
  }
}


private static final String MSP_HEADER = "$";

private static final int
  MSP_IDENT                =100,
  MSP_STATUS               =101,
  MSP_GET_GSM              =102,
  MSP_LOGGING              =103,
  MSP_SMS                  =104,
  MSP_SET_GSM              =106,
  MSP_SET_RAW_GPS          =201,
  MSP_ACC_CALIBRATION      =205;

public static final int
  IDLE = 0,
  HEADER_START = 1,
  HEADER_END = 2;
;

int c_state = IDLE;

byte cmd;
int offset=0, dataSize=0;

int p;
byte[] inBuf = new byte[frame_size_read];

int read32() {return (inBuf[p++]&0xff) + ((inBuf[p++]&0xff)<<8) + ((inBuf[p++]&0xff)<<16) +
((inBuf[p++]&0xff)<<24); }
int read16() {return (inBuf[p++]&0xff) + (inBuf[p++]<<8);}
int read8()  {return inBuf[p++]&0xff;}


float accSmooth[] = new float[3];
int  GPS_numSat;
float GPS_coord[] = new float[2];
long  GPS_date, GPS_time;
float  GPS_altitude, GPS_speed;

void serialEvent(Serial p) {
  processSerialData();
}

void processSerialData() {
  int present=0,mode=0;

  if (g_serial.read() == '$') {

    g_serial.readBytes(inBuf);
    p=0;

    if (inBuf != null) {

    int header = read8();  // print command header


    switch(header)
```

```
  {
   case MSP_STATUS:

  currentX = read16();
  currentY = read16();
  currentZ = read16();


  xAxis = insertValueIntoArray(xAxis, currentX, readingPos, totalReadings);
  yAxis = insertValueIntoArray(yAxis, currentY, readingPos, totalReadings);
  zAxis = insertValueIntoArray(zAxis, currentZ, readingPos, totalReadings);
  readingPos = readingPos + 1; // increment the array position

  System.out.println( "x : " + currentX + " y : " + currentY + " z : " + currentZ );

    GPS_numSat = read8();
    GPS_date = read32();
    GPS_time = read32();

    GPS_coord[0] = (float)read32()/10000;
    GPS_coord[1] = (float)read32()/10000;
    GPS_altitude = (float)read32()/100000;
    GPS_speed = (float)read32()/100000;

    System.out.println( "Lat : " + GPS_coord[0] + " Long : " + GPS_coord[1] + " Time : " +
GPS_time);
    //For showing the longitude and latitude of the current position
   break;

   case MSP_GET_GSM:
    SMS = ""; VEHICLE="";

    txtAxisX.setText(str(read8()));
    txtAxisY.setText(str(read8()));
    txtAxisZ.setText(str(read8()));

    int lenx = read8();
    for (int x=0; x<lenx; x++)
     SMS = SMS + char(read8());

    lenx = read8();
    for (int x=0; x<lenx; x++)
     VEHICLE = VEHICLE + char(read8());

   txtSMS.setText(SMS);
   txtVEHICLE.setText(VEHICLE);
   break;

   default:
    String myString = g_serial.readStringUntil(LF);
    System.out.println( myString );
  }
  }
 }else
 {
  g_serial.readStringUntil(LF);
 }

}

public void evaluateCommand(byte cmd) {
 int icmd = (int)(cmd&0xFF);
```

```
switch(icmd) {
  case MSP_IDENT:
      System.out.print(read8());
      System.out.println(read8());
      break;
  case MSP_STATUS:
      //cycleTime = read16();
      //i2cError = read16();
      //present = read16();
      //mode = read32();
      break;

  default:
      //println("Don't know how to handle reply "+icmd);
  }
}

public void controlEvent(ControlEvent theEvent) {
  if (theEvent.isGroup()) if (theEvent.name()=="portComList") InitSerial(theEvent.group().value());
// initialize the serial port selected
}

public void bLOG() {

  if(init_com!=1) return;
  buttonLOG.setColorBackground(green_);buttonLOG.setColorBackground(green_);

  g_serial.clear();
  g_serial.write(MSP_HEADER);
  g_serial.write(MSP_LOGGING);
  g_serial.write(LF);
}

public void bSMS() {

  if(init_com!=1) return;
  buttonSMS.setColorBackground(green_);buttonGET.setColorBackground(green_);

  // Send test SMS
  g_serial.clear();
  g_serial.write(MSP_HEADER);
  g_serial.write(MSP_SMS);
  g_serial.write(LF);
}

public void bGET() {

  if(init_com!=1) return;
    g_serial.write(MSP_HEADER);
    g_serial.write(MSP_GET_GSM);
    g_serial.write(LF);

}

public void bSET() {

  if(init_com!=1) return;

    g_serial.write(MSP_HEADER);
    g_serial.write(MSP_SET_GSM);

    String SMS = txtSMS.getText();
```

```
    String VEHICLE = txtVEHICLE.getText();
    String AxisX = txtAxisX.getText();
    String AxisY = txtAxisY.getText();
    String AxisZ = txtAxisZ.getText();

    g_serial.write(Integer.parseInt(AxisX.trim()));
    g_serial.write(Integer.parseInt(AxisY.trim()));
    g_serial.write(Integer.parseInt(AxisZ.trim()));

    g_serial.write(SMS.length());

        for (int x=0; x<SMS.length(); x++)
         g_serial.write(SMS.charAt(x));

    g_serial.write(VEHICLE.length());

        for (int x=0; x<VEHICLE.length(); x++)
          g_serial.write(VEHICLE.charAt(x));

    g_serial.write(LF);
}
```