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Penerbit Akademia Baru

Journal of Advanced Research in Computing and Applications

Journal homepage: www.akademiabaru.com/arca.html

ISSN: 2462-1927

MotoSOS: Accident Detection for Motorcycle Riders Using Motion Sensors

Open Access

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ABSTRACT

Malaysia currently having one of the highest motorcycle accident rates in the world. A fast response to an accident is needed in making sure the lives of an accident victim is saved. Motorcyclist or rider often involved in accident in rural area which no bystander or emergency services may not be available. Most smartphones nowadays were embedded with sensors like accelerometer, gyroscope, barometer, global positioning system (GPS) and many more. With these embedded sensors, they can be used to measure many activities. The combination of these sensors can detect rider's accident, even if there is no witness or bystander to help. Thus, emergency services can arrive to the location in a short time. Accelerometer can sense multiple data such as acceleration and linear acceleration. To detect rider's position, gyroscope is used to detect the orientation of the smartphone. By having both sensors, an accident can be easily detected, and the application will send SMS to emergency contact. This may help the survivability of the motorcycle riders. This paper aims to develop a mobile application that can detect accident using motion sensors which are accelerometer and gyroscope.

Keywords:
Mobile apps; motion sensor; accident; motorcycle

1. Introduction

Motorcycle has been a favourite method of transportation especially in ASEAN. This popular trend mostly because of the low price of vehicle ownership and maintenances compared to other type of vehicle. However, apart from becoming a daily transport, it is also used as a leisure activity [1]. Among ASEAN countries, Malaysia has the highest road death risk (per 100,000 population) with more than 50% of that belong to motorcyclist with most of the accidents occur on rural roads with low traffics [6].

When any type of accident happens, a victim needs an immediate attention. A fast call to emergency services may determine the survivability of the victim. In an accident situation, a swift action of calling to an emergency services are vital. A reduction of 10 minute of response time for a rescue to come to the accident can contribute to a 33% reduce of mortality [11]. This shows that time is a valuable thing to an accident victim.

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People carry their smartphone everywhere and smartphone has become one of the necessities nowadays. Today's smartphone not only meant for calling and texting but has numerous functions to it. Thanks to sensors that have been installed to our smartphones that we are now able to detect activities like walking, jogging, sitting and many more [5]. Common sensors like accelerometer, gyroscope, barometer, global positioning system (GPS) and many more can be easily found in smartphone nowadays. These sensors can be used to detect mentioned activities. For example, combination of accelerometer and GPS can detect if someone is riding a bike, or on a train or on a car [8].

This paper is focused on the development of an Android mobile application called MotoSOS. MotoSOS provides motorcycle riders an application that emergency Short Messaging Service (SMS) will be sent to emergency contact number if the application detects an accident. This application uses integrated motion sensors that comes in most modern smartphone, which is accelerometer and gyroscope.

2. Literature Review

Traffic Accident Response

In an accident, there are many parties involved. They are victims and bystanders. In most situation, bystanders will make an emergency call if the victim is unable to make a call. Fig 1 shows a common accident response.

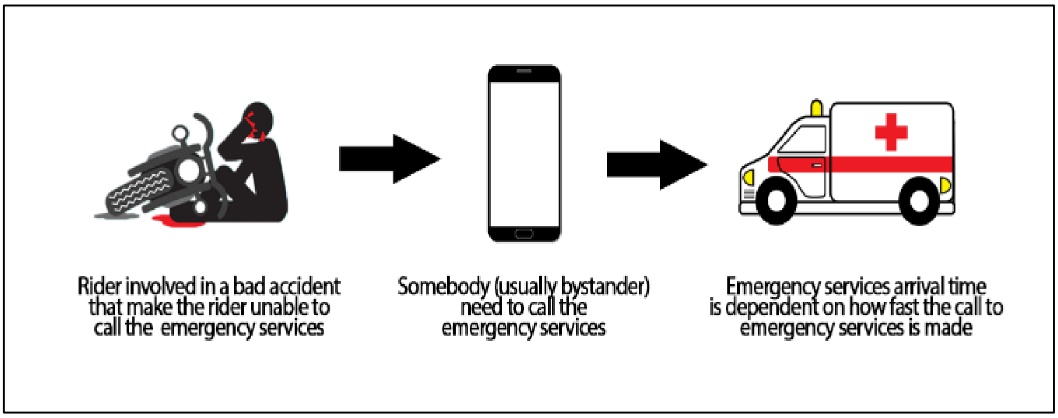


Fig. 1. Common accident response

More than half of accident situation that the victim being late to discovered after suffering and accident with 40% of it being more than an hour [10]. Presence of bystander or witness at the scene is very important to help and make call to the emergency services. But in some situation (especially in rural area), rider involved in accident with no bystander and witness. In Malaysia, 61% of motorcycle accidents fatalities occur in rural areas with only 8% of fatalities occur in urban areas [6]. One of the reasons high rate of fatalities in rural areas is because of the absence of emergency services, late response of emergency services and late report of accident to emergency services.

Also, the next of kin needs to be informed. The most common way to get the next of kin information in a motorcycle or even car accident is by checking the victim wallet or phone for any important information such as emergency contact phone number or victim's address. If information cannot be found, bystander will spread the news via social media or social messaging such as Facebook or WhatsApp while the police will use newspaper to contact the next of kin (nearest relative) or people who may know the victims. Fig 2 shows bystander is searching for a victim's next-of-kin on Facebook. This post is shared on local group which is Pontian (Malaysia) community in

Facebook. It is hard to identify the next-of-kin as the local people there might not know who's the victim is.

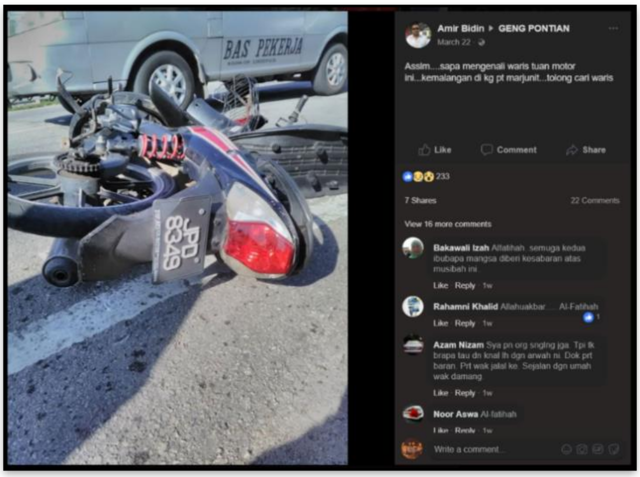


Fig. 2. Bystander searching for victim's next-of-kin on social media

To solve this problem, we developed an automatic accident detection mobile application called MotoSOS. This application can greatly reduce time taken for victim waiting to be discovered by bystander, to seek help from emergency services for medical attention. The application uses accelerometer and gyroscope embedded on smartphone to detect an accident and send a notification to emergency contact that later will call emergency services for the victim.

Android Sensor

Android platform supports mainly three broad categories of sensors: the motion, position, and environment-based sensors. This categorization is done based on the type of physical quantity detected and measured by the sensors.

Motion Sensor

Acceleration and rotation of devices can be gathered using motion sensors [13]. Motion sensors used to measure any kind of motion that can be either linear or angular movement in any direction [9]. Usually, the sensors will produce values in x, y and z axes, with rotational vector having an extra fourth axis, which is the scalar component of the rotation vector. Example of motion sensors in Android operating system: accelerometer, gravity, linear acceleration, gyroscope, step detector, step counter, significant motion and rotation vector.

Accelerometer

An accelerometer is an electromechanical device used to measure acceleration forces such as sense of movement and vibration on smartphone [4]. This sensor figures the acceleration on the x, y and z axes include both physical acceleration (changes in velocity) and the static gravity. This sensor is used in many researches and application to detect impact or fall. An accident can be detected using accelerometer by sensing a sudden large variation of linear acceleration. Fig 3 shows the axis measurement of accelerometer.

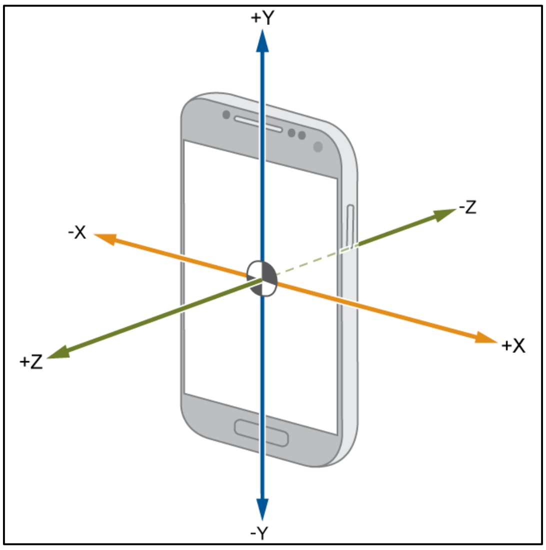


Fig. 3. x, y and z orientation axes relative to a typical Android phone; Source: Mathworks.com

Gyroscope

Gyroscope or gyro sensor is one of the staples sensors in smartphone. This sensor popularized by the implementation on iPhone 4. Gyroscope work with conjunction with accelerometer which adds additional dimension information which is tilt or rotation of the smartphone. This works by measuring the angular rotational velocity. A smartphone gyro used a smaller, miniature size of gyro sensor called MEMS gyroscope. Fig 4 shows the axis of measurement.

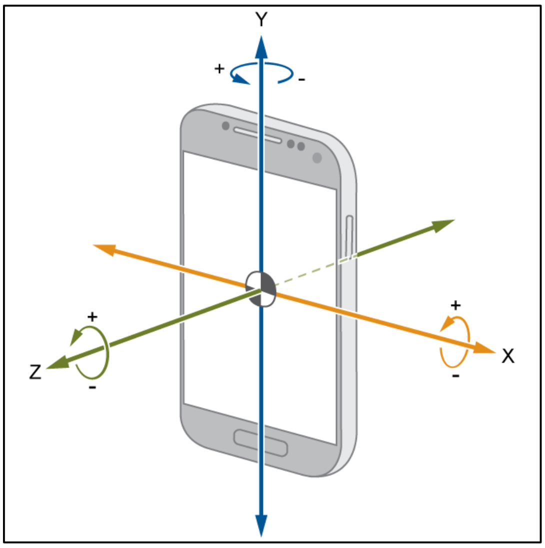


Fig. 4. Positive orientation of x, y, and z axes for typical Android phone; Source: Mathworks.com

Position Sensor

Position sensors data can be used to measure physical position of the phone relative to world. Position sensors values is measured in x, y and z axes. One of the applications of this kind of sensors is using magnetometer to detect the north pole used in compasses application [9]. Other example of position sensors is proximity sensors and game rotation vectors.

Environmental Sensor

Environmental sensors can be used to measure temperature, humidity, light and air pressure near the phone which basically all environmental properties. This type of sensors only produces single values [9]. Example of environmental sensors is ambient temperature sensor, barometer and light sensors.

Similar Applications

White *et al*., [12] presented an application called WreckWatch. This application used primarily accelerometer and acoustic data to detect an accident. WreckWatch use dedicated server developed using Java/MySQL with Jetty and Spring Framework. This allow the application to show the accident information through several interface such as Google Maps and JSON web services. Thus, make the application highly customizable and accessible across multiple platform, not just the smartphone. The application makes use of acceleration data with acoustic data to detect an accident. Unique for this application is the author use acoustic sensors to detect a deployed airbag situation which will create a loud noise. The author created multiple situation to make sure no other normal situation reach the 160dB range of airbag deployment.

iBump: Smartphone Application to Detect Car Accidents is an application developed by Aloul *et al.*, [2]. The system built on Android platform with supplement of web-based application. The user needs to enter their information such as name, mobile number and blood type when the application detects an accident with an addition of option for user to register a false alarm in case of false accident detection. The web-based application supplements the mobile application by providing a map interface showing real-time data of accidents, user tracking and various report of current accident, their location and trends. This application only relies on accelerometer data for their accident detection module. Dynamic time warping (DTW) technique is used to analyses and determining what the value in the case of accident.

Both these applications are designed for car. But both have the same goals which is creating an application to detect an accident in real-time, all of it have their own way of implementation.

3. Research Methodology

MotoSOS is a mobile application that can detect an accident in a real time situation by using smartphone own sensors which is accelerometer and gyroscope sensor. This mobile application is developed and used by the motorcycle rider. There are 4 modules: user account management, emergency contact management, medical information management and accident detection module.

Process Flow

This application will run in background. Values from accelerometer and gyroscope are retrieved from time to time. If the values more than $70 m/s^2$ (accelerometer) and higher than 2 or less than -2 (gyroscope), the application will detect that accident has occurred. Then, the application will send SMS to emergency contact number together with the location of the accident. Emergency contact will later call the emergency services. A simplified process flow of the system can be drawn as shown in Fig 5.

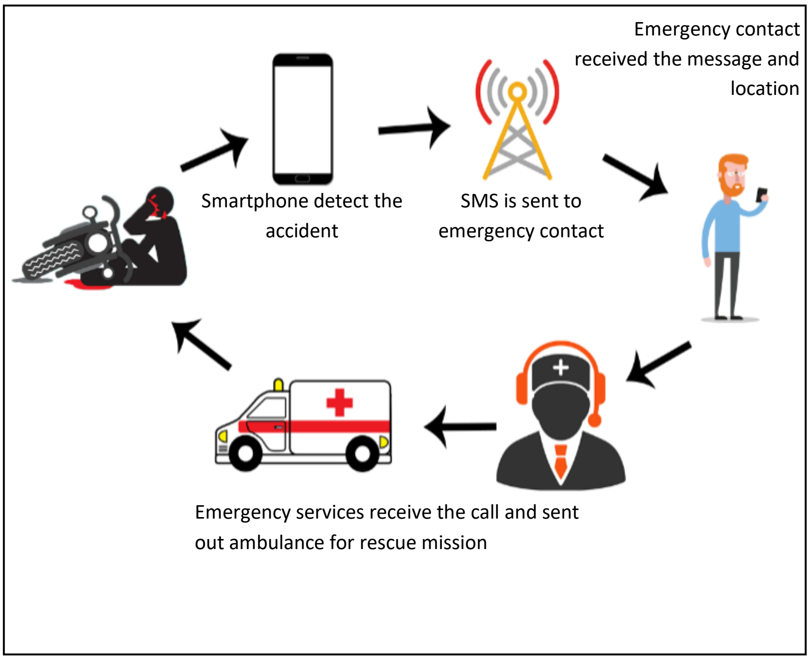


Fig. 5. Process flow

Design

We designed the application in three components: model, view and controller as shown in Fig. 6.

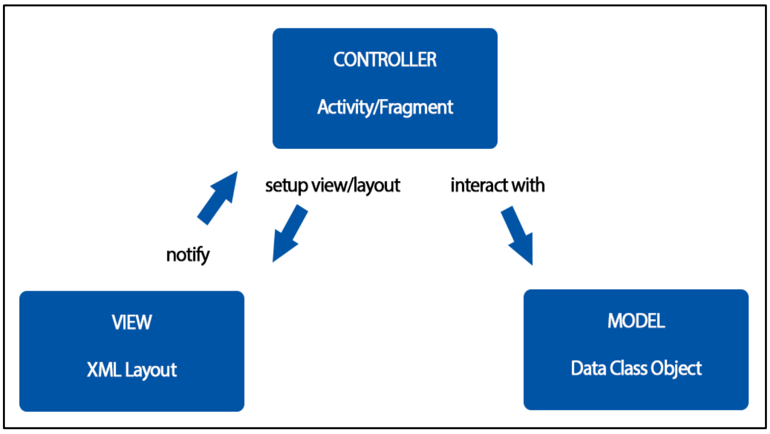


Fig. 6. Android Model-View-Controller Architecture

Figure 7 shows the system component diagram which represent the three-layer internet architecture between the user interface layer and the domain layer which is the business logic and the data access layer.

Data access layer. This layer contains the data access services, server and the database. As the system using Firebase as the database, this layer all handle by Firebase on the cloud.

Business layer. All the logic process situated. All the business rules and process are done and the API that the system used. The system frameset or controller will be the activity and fragment which is using JAVA. There also usage of Google API in the code. Then, all the process is done on Android platform.

User interface layer. Application view will be used with XML as the language for the code.

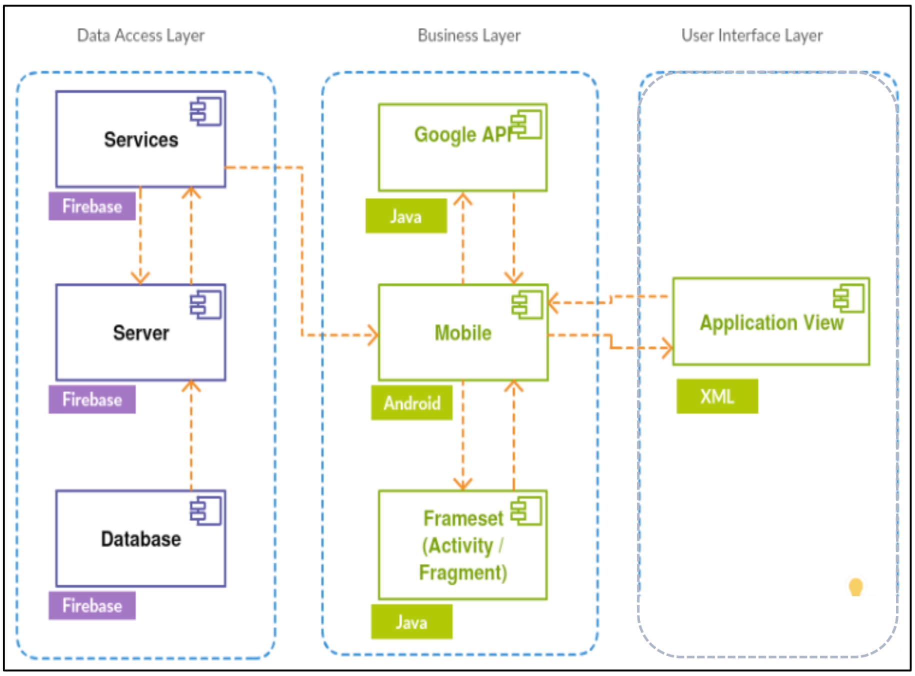


Fig. 7. Component Diagram

Accelerometer and Gyroscope Data Manipulation

To get values that indicate accident has occurred, a series of experiment was done. An existing application is used to record the data. This application is from Golpashin [3] which is called Sensor Record that can be downloaded from Google Play Store.

To determine the point of data for triggering accident detection, few experiments has been made. For accelerometer data, the experiment is consisting of recording of phone linear acceleration data in 4 situations: normal ride, throwing the phone to the ground, dropping the phone from desk and simulated accident situation. Table 1 shows the result.

Table 1
Accelerometer Experiment Results

Experiment Situation	Maximum MA Value (m/s^2)
Normal ride	36.92
Simulated	72.69
Throw	65.52
Desk drop	38.79

From Table 1, it can be concluded that the value that need to trigger the accident detection module is more than 70m/s^2. This is a preliminary value as many tests needed to be made, and the experiment needed to be test using other smartphones as the calibration may varied.

For gyroscope value, only the x-axis is being used. The x-axis value represents the tilting of the smartphone that correspond to the tilting of the rider body. Same application used for the experiment determining the value of gyroscope. The experiment consists of determining the value of gyroscope during riding and the maximum threshold for normal riding. From that, the value that will be used is the value more that the threshold during normal riding. Two type of motorcycle used in this experiment. A sport bike which is KTM RC250 and a moped which is Yamaha Nouvo LC. From the experiment, the maximum value of gyroscope for normal riding is around 2 and -2. Therefore, it can be concluded that value higher than 2 or less than -2 will be the trigger point for the application to execute accident detection.

Development

The application is developed in Android Studio for both of front-end and the back-end. The user interface design uses XML language. The design is done by using integrated graphical editor from Android Studio. For logical development, Java language is used as it is the native language of Android. The application uses activity and fragment style of Android design. This means that the application implements one main activity that make use of navigation drawer that enable the application to use multiple fragment inside that activity. For the database, Firebase is used. It is the preferred database in Android mobile development. This database platform only offers NoSQL type of database. This is suitable for this application as the database design is not complex with small number of entities.

3. Results

MotoSOS is an application that supposed to be running in the background. If values of accelerometer and gyroscope reach the trigger point, the application will detect an accident and send SMS to emergency contact number together with the location of the victim. Fig 8 shows the main screen. User must switch it on so that the application will run in the background.

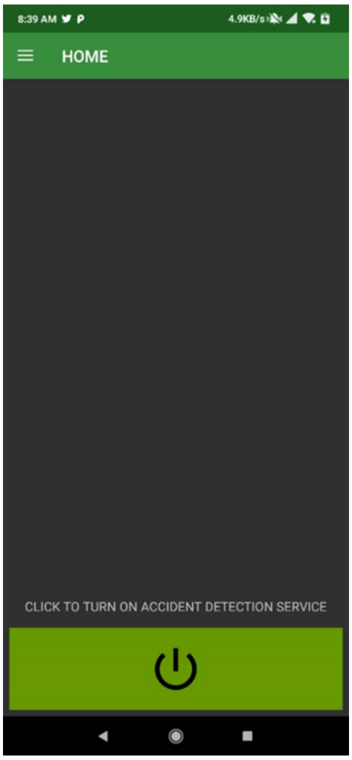


Fig. 8. Main screen

User must enter his/her details which include name, current address, emergency contact number, medical condition, allergy and medication (Fig 9-10). This information may enable emergency services and first responders to obtain emergency information in the case of emergency.

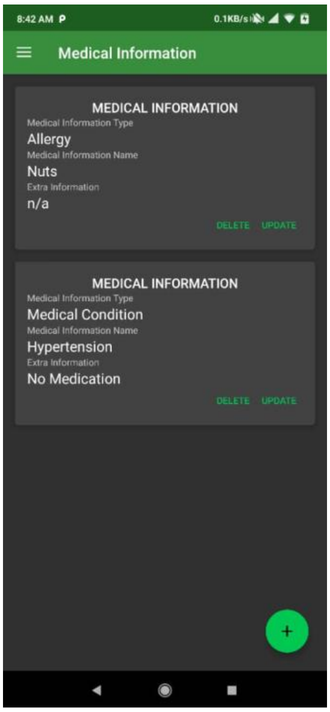
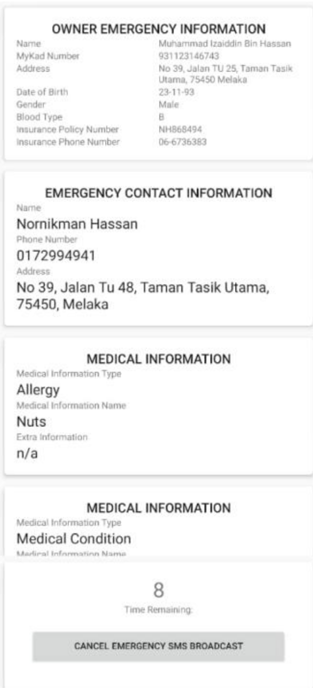


Fig. 9. Emergency contact **Fig. 10.** Medical

The application will display the user's information if accident is detected. User is given 30 seconds to cancel an SMS from being sent to emergency contact number. If no cancelation being made, the details are sent to the emergency contact number (Fig 11-12).



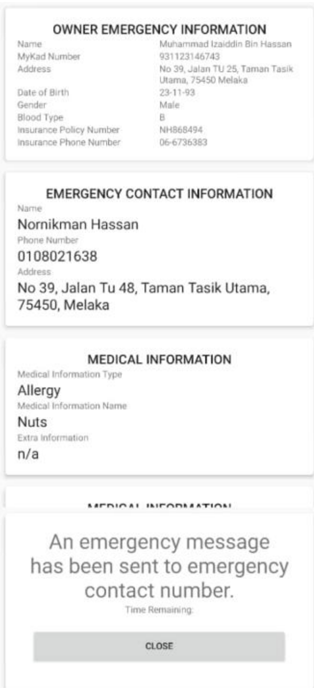


Fig. 11. Accident detected **Fig. 12.** SMS is sent

Also, location of the victim is attached in the message, as shown in Fig. 13.

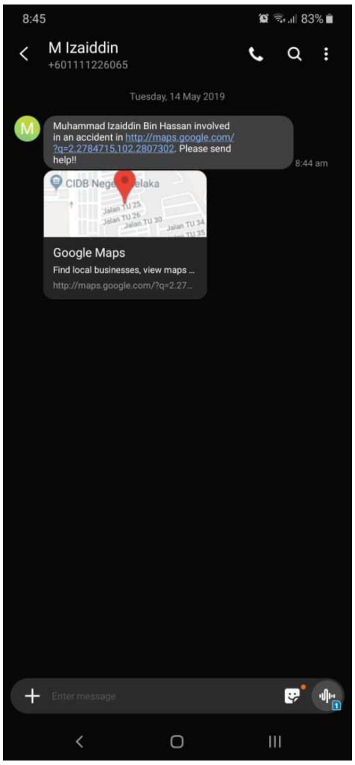


Fig. 13. SMS received

The emergency contact may refer the location sent via SMS and get help from emergency services.

4. Conclusion

To sum up, this project will significantly benefit to the motorcycle riders, closest relatives and emergency services. This mobile application will help them in post-accident situations in which it will provide a quicker way to broadcast an accident that occur to them and get their emergency contact as well as connecting them to the emergency services.

The application also will notify the closest relatives if the motorcycle riders involve in an accident. The automation process of contacting closest relatives will cut a lot of buffer time to find for emergency contact.

Furthermore, personal information that have been provided in the application will help in giving suitable treatment and medicines once the victim hospitalized in which if the victim has allergy on certain medication, far away from their hometown or absence of any closest relatives. This will benefit the emergency services to get details information about the victim. The successful of this application will totally give great impact to the society especially towards the safety of the motorcycle riders.

5. Future Work

Due to the limitation of time, there are certain area that could improve the application in the future such as liaise with emergency services to call for ambulance. A great corporation with emergency services will put more trust on people to use this application. Further to improve is by creating an automatic machine learning algorithm in which the application can record all log and values of the traffic collision detection algorithm. It will improve accuracy over time.

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