Location Tracking of Accident Detection on Expressway for Informing Nearest Rescue Service

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***Abstract* – In order to reduce the risks related to the expressway vehicle accidents, it is considered that the timely hazard information and the prompt rescue operations are the vital elements to save the victims and users of the expressway. In addition, the modern technologies such as video surveillance, alarm units, high-technology sensors assist to detect the victim's latest position and send the fast notification to the rescue services. In this paper, to detect the victims of automobile accidents, the Motion Sensing Method assists to evaluate the values received from the sensors of accident detection system to categorize the level of accident such as minor, major and critical while the Difference Angle Method supports to indicate the accurate angle direction of the vehicle based on the GPS values. To enhance the accuracy of data analyzation, the Modern Positioning Method is opted to track the victims constantly by using the signals, which are transmitted from the victims' smartphones to the base stations such as available mobile networks. Moreover, the Object Detection in Fence Algorithm assists the victims to receive the medical support from the rescue services within a short period of time. This system is aimed to be a user-friendly system; thus, the prescribed algorithm and methods are dedicated to apply with built-in technology sensors. Therefore, the location tracking and accident detection system can easily identify the precise accident place by using Geofence technologies and GPS, connecting with the mobile network.**

Keywords— Accident Detection, Sensors, Rescue Service, Geofence, GPS, Dataset

I. INTRODUCTION

All around the world, the road accidents affect the rising of death rate among people these days. The main cause of death is not only the difficulty in observing the accident location but also delay in triggering the informing message to the emergency services such as fire stations, hospitals and so on. Hence, the punctuality is a crucial action to deliver the lifesaving services.

In every country, the expressways are regarded as the one of the main infrastructures to connect the urban areas and country sides to promote country's economy, communication and tourism industry. In Myanmar, the Northern states and Southern divisions are connected with thirty six (36) roads, while the people use forty nine (49) roads to travel and transport good and services between Eastern states and Western regions. Recently, the percentage of vehicle accidents has been significantly raised. According to the "Road Safety in Myanmar 2017", Myanmar Police Force declared that the fatality rate related to crash accidents was in excess of doubled within 8 years, which was from 1853 accidents occurred in 2008 to 4688 in 2016. The progression of country's economy development leads to inspire the civilians occupied more and more vehicles, so it is assessment the death rate related with crash accidents may reach 9,000 in 2020.

To diminish the increasing rates of injury and death related to the expressway accidents, the people start looking for the efficient and effective way to detect the accident victims and inform the rescue services to deliver the medical assistance. Therefore, the mobile smartphones embedded with the powerful detection sensors are contemplated as the suitable devices to obtain an information of accident and convey the prompt rescue services.

The accident can be validated by using the values collected from accelerometer and gyroscope sensors, and then the direction of vehicle and the position of accident victim can be easily and efficiently identified by connecting with the available mobile network and Global Positioning System (GPS). By using Geofence technology, the updated emergency unit information such as points of contact are easily obtained, and the alert message will be sent to the nearest rescue services. To diminish the frequency of receiving the false alarm, the Motion Sensing Method is applied in this expressway traffic accident detection system. Besides, the Difference Angle Method assists to indicate the direction of vehicles while Modern Positioning Method is used to validate the accurate position of the accident. Once the accident location is confirmed, the Object Detection in Fence Algorithm is applied to select the nearest rescue services and immediately report the accident status.

II. RELATED WORKS

The other experiments related to the systems of tracking locations and detecting accidents are as followed:

In 2004, Marwan Abboud., Lina Mariya Abou Jaoude. And Ziad Kerbage.[1] achieved "Real Time GPS Navigation System" by using modernized procedures. Rather than utilizing a table at every point, the driving routes are produced by evaluating the geometrical figures on the map. None of the radio signals are needed to correct the error of GPS and match them on the map. This system only depends on the basic GPS signals and the geographic locations of the road network. The vulnerability of this system is that it can send the accurate guidance to the drivers only in Beirut city and not in other areas. In addition, the embedded GPS receiver is not able to identify the drivers' locations anywhere in the world if the weather condition is bad.

In 2005, Huub HC Bakker, Ken A Mercer and Wyatt H Page. [2] "A Review of Position Tracking Methods", It was aimed to summarize the variety of position tracking methods and their pros and cons. The illustrated methods were modified to improve the system's design to trace the objects' positions and, the self-powered wireless electronic devices were also utilized to evaluate the information received. However, to receive the accurate result of the object's position, it is crucial that the base stations and the node of the object must synchronize all the time so that the

timer could be started once the signal was transmitted. Inaccurate measurements of the time variation will cause the incorrect computation of distances as well as the measurement of wrong positions. Besides, it is also needed the multiple base stations, which must be immobile, to receive the precise result of the position.

In 2011, Chris T., White J., Dougherty B., Albright A. and Schmidt DC.[3]"WreckWatch", a model of smartphone-based client/server application cannot recognize the risk of accident when the car is driven with lower speed, which is under the configured speed limitation of the application.

In 2013, Danish Karim and Jaspal Singh [4] introduced the "Development of Automatic Geofencing and Accidental Monitoring System based on GPS Technology that could detect the accident and protect the vehicles from the theft. However, it is not indicated where and how the contacts of emergency services are kept although the system was functioned to transmit an automated message to the rescue services. Therefore, it is highly possible that the users may obtain the limited information from the sender. The remainder of the paper is organized as follows.

The research methodology is expressed in section III while the purpose of using Motion Sensing Method, Difference Angle Method, Modern Positioning Method and Object Detection in Fence Algorithm, and the components of Geofence technology is explained in section IV. Section V explains the technologies intended to use in this research. Then, in section VI, the experimental results are discussed. The conclusion of this research is stated in section VII.

III. Process Flow of Research Work

The accident detection system is operated in two main stages, which are collecting and processing the data, and connecting to the nearest rescue services. First of all, the values from Accelerometer, Gyroscope, GPS are obtained by applying Motion Sensing Method and then, managed those values in the dataset, which is specially created for accident detection system. Next, with the usage of Difference Angle Method, the accident detection system analyzes the collected data by comparing with the predefined dataset to specify the level of accident, which is defect of minor, major or critical. Then, Modern Positioning Method assists to validate the position of user's vehicle by determining the signals travelling between the user's phone and GPS. When the accident is confirmed, the system applies the GPS values received from accident detection dataset and then, applies the Object Detection in Fence algorithm in the Geofence technology to generate the circular polygons, which indicate the accident location as a center point. Finally, the system retrieves all rescue service's contact information in the selected polygon from the dataset of rescue facilities and then, seeks the nearest rescue service's contact point from the accident spot.

If there is rescue service unavailable in the first polygon, then the Geofence creates the new polygon with broader edges until it finds the nearest rescue service from the accident location. Then, the system informs the rescue service, which describes accident location, the information of user and vehicle with level of incident.

The server's side workflows highlight how the data of user's information, incident information and the rescue services will be gathered and managed. Then, the user's side workflows perform the prediction and determine the related activities. To obtain the optimum result of prediction, sensor projected data maintained in integrated database such as fixed data, rates of false alarm and death of accidents performs the main roles to predict. The process flow for the research work is shown as Figure 1.

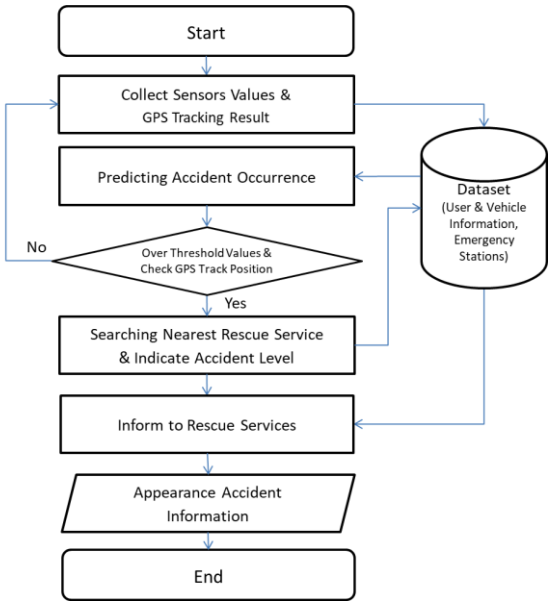

Fig. 1. Process-Flow Diagram of Accident Detection System

IV. Detection and Searching Methdology

A. *Motion Sensing Method*

To reduce the level of data insufficiency between the sensors, Motion Sensing Method is selected to promote the dependability of data quality by combining the data received from different sensors while there is a concern of data deficiency between the single sensors. The previous related experiments describe that the data produced from automated sensors cannot be completely accurate most of the time. Thus, in this method, the data will be received from different sources such as automated sensors, historical sensors data maintained in the central database and the non-automated sensors, examined and evaluated to attain the best output. To get the premium input data is crucial in this system. The following Motion Sensing Method can be used to receive the most relevant outcome of the accident detection process:

```
Accelerometer Threshold value
ATx, ATy, ATz = getAccelerometerValuesByCarType();
Gyroscope Threshold value
GTx, GTy, GTz = getAccelerometerValuesByCarType();
predictMarks = 0;
While(true)
    Accelerometer Ax, Ay, Az = sensors value;
    Gyroscope Gx, Gy, Gz = sensor value;
    If not Ax, Ay, Az in range of ATx, ATy, ATz
        PredictMarks += 1;
    If not Ax, Ay, Az in range of GTx, GTy, GTz
        PredictMarks += 1;
    If PredictMarks > 0
        AlertAccidentDetect
```

B. *Difference Angle Method*

In order to confirm the more accurate result of the accident, a difference angel method is opted to applied along with the Motion Sensing Method in this paper. Although the GPS can provide the latitude and longitude values of the vehicle, it cannot indicate the angel direction of the automobile. Thus, the difference angel method retrieves the values from GPS and then, predicts the direction of vehicle based on those values. All those GPS values are stored in the user's smartphone. When the accident occurs, the GPS latest value is compared with its most recent value. If the accident occurs at 4:10:10 p.m., the method retrieves and compares the values captured at both 4:10:10 p.m. and 4:10:09 p.m. Even if the values received from accelerometer and gyroscope exceeds the accident threshold value set in the system, it immediately obtains the newest GPS value and judges it with the nearest previous value of GPS. In this way, the accident can be validated accurately, and also the false alert is able to avoid.

$$\text{Slope1} = \frac{||Y_B - Y_A||}{||X_B - X_A||}$$

$$\text{Slope2} = \frac{||Y_C - Y_B||}{||X_C - X_B||}$$

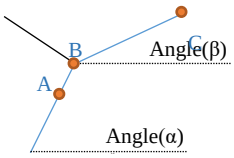

Fig 2. Angles between 2 Nodes of GPS

When this angle difference between current link and the next link is computed, directions will be provided according to the Rule 1 is when the Difference Angle Є{(0°;180°) Or (-360°;-180°)}➔ "LEFT Turn" and Rule 2 is when the Difference Angle Є{(180°;360°) Or (-180°; 0°)}➔ "RIGHT Turn". If there are several left or right turns existed, GPS technology must correctly inform to the system.

C. *Modern Positioning Method*

The Modern Positioning Method assists to track the users' position by determining the signal travelling time from the smartphone to the available receivers such as the phone networks or GPS. In this method, the positioning of the user can be obtained by applying the relationship between time, distance and velocity of the signals transmitted from the user's phone. The receiver can compute the user's position by comparing the sources of signals, which is similar the method applied in GPS. The equation for this method is shown as below:

$$d = v.t$$

Where d indicates the distance between the user's mobile device that emits the signals and the receiver, while v and t are stated as the velocity of the transmitted signals and the travelling time of those signals to the receiver.

D. *Object Detection in Fence Algorithm*

The following algorithm is intended to create the virtual boundary on geographical for searching and sending the alert message to rescue teams.

Once the accident is validated, it is created an approximate of 1000 square meters range of polygon and the center point of the polygon range is marked as accident spot. By using Object Detection in Fence Algorithm, the contact points of rescue services near the accident spot are started to seek. If the rescue contact point is unidentified, new polygon with larger edges is created by using Geofence. Then, the rescue contacts will be sought by applying Algorithm until the nearest one is received. Then, the alert message indicating the information of accident victim and the accident location are sent to the nearest emergency or rescue service. In this paper is that the system informs the rescue teams can take a prompt action to victims of accident within the shortest period.

Three input values are marked as (P, Q and S) in Object Detection in Fence Algorithm. P is stated as a location of accident and Q is noted as polygon created to enclose P. S points out the available rescue services marked on Google Map. In some cases, the early values of inside are specified as 'False' when the searching process initiates in Polygon. However, the final inside value will be indicated as 'True' if S falls within Q or else, it will be shown as 'False' if S is not detected in the range of Q.

Algorithm:
Input: P is incident point, Q is polygon, S is rescue service contact
P denotes the location of accident
buf is a buffer distance.
Output: true if S contains Q, otherwise false
1: count = 0
2: R is an infinite ray in the +y direction, originating at P
3: for all edges e in Q do
4: if S is within buf of ex then
5: ex,buf = ex -2 * buf
6: else if S is within buf of e or ebuf then
7: return false

Before starting any loops from point P, the count is set as '0' by system. Once the system detects the accident, the countless rays known as 'S' will be transmitted in +y direction from the point of origin (P) to the edges of polygon (Q). The looping process performs between point of origin (P) and the edges of polygon (Q) until the target point of interest (R) is identified. When the system identifies the target point of interest or the closest rescue service (R) in Polygon (Q), the looping process is stopped, and the value is stated as 'True'. If R cannot be found in Q, the current looping will be discontinued, and the value is stated as 'False'. Afterwards, the larger polygon is created again to start the new looping process till R is found.

E. *User And Vehicle Information*

To accelerate the delivery of efficient rescue services, users need to provide the personal information of driver and passengers (i.e. name, ID, date of birth, blood type, contact numbers) at the beginning of the expressway trip. The user information is installed as one-time input. For instance, the user may require the blood transfusion during an accident, so the rescue services can quickly prepare the relevant blood type for the patient.

Not only the users' personal information but also the vehicle information is also needed to share before starting the trip. When the accident arises on the expressway, user can trigger the accident detection system to deliver the message including the precise place of incident occurred on the chosen way of the trip. Then, the system will retrieve the following data from the dataset before contacting the rescue service.

F. Geofence

Geofence sets up the virtual boundaries of an area where the accident location. With the aim of receiving the precise point of interest, the user must provide the latitude and longitude of accident spot as well as the adjustment of radius. Since the Geofence is a useful feature to detect the high-risk locations, so it defines the virtual boundary with the provided information near the point of interest. It is also operated to deliver the alert message to the nearest rescue service from the location of accident victim.

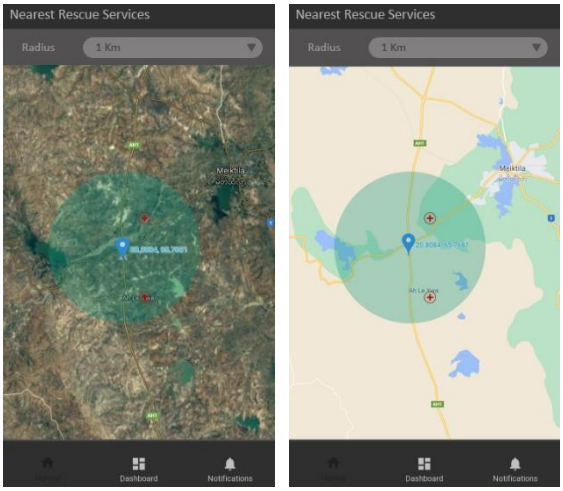

Fig. 3. Location of Accident and Available Rescue Services

G. Accident Detection Dataset and Rescue Service Dataset

An accident detection dataset, in which the primary data obtained from the built-in sensors, is required to obtain and consider the accident status. After validating the status of accident, the latest data from calibration sensors is sent to the core system to automatically update the dataset. Then, the datasets evaluate whether it is an accident or not by analyzing the values collected from those sensors such as accelerometer and gyroscope.

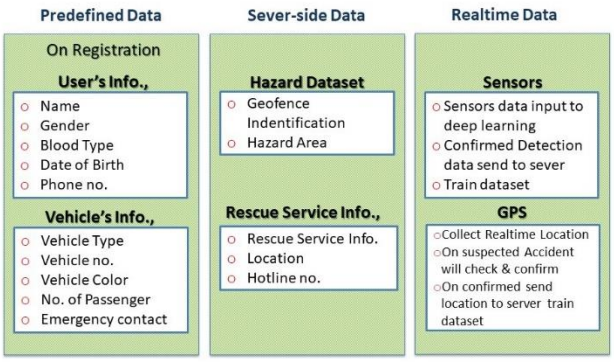

Fig. 4. Sample of Sever side Dataset

Rescue Service Dataset connects to Geofence for maintaining the emergency service information such as the contacts of expressway police stations, regional clinic and hospitals and so on. An example of rescue service dataset is shown in Figure 4. After confirming the accident, information including the details of last GPS location will be automatically inform to the nearest rescue services. Geofence is able to retrieve this dataset anytime because the rescue service dataset is always updated on the server.

V. Technologies Usage

The below mentioned technologies are intended to use in this research.

In this paper, smartphones are selected as the main subject because they portable machines installed with strong technologies and, everyone can afford to pay for the price. The Android source code is an accessible open-source mobile operating system, but not allowed for using the personal or financial advantages. Since it is a basic Android Integrated Development Environment (IDE), Android Studio assists Android developers all the required tools to write the codes with auto-completion tools.

Comparing with other programming languages, Java is one of the most convenient languages with the large set of multifunctional class libraries (for example, connectivity, sensors). These libraries are reusable in most applications, so the developers can save their time not to rewrite the codes and, also avoid some unexpected errors.

Geofencing produces the fixed or modified virtual boundaries in live geographic places. Comparing with the common framework API, Google Location API provides the powerful and high-level framework to choose the appropriate location provider and power management automatically. Unlike the common APIs, Google Location API possesses the activity detection feature.

Due to the accessibility to Google Maps Service, the Google Maps Android API is also chosen to show Maps, collect the users' responses at the selected location and provide the relevant information that the users request. By using HTTP request, an information about the topography as well as the significant point of interests throughout the chosen route are presented. Contrasting with Google Places API Web Service, Google Directions API computes the total length of itinerary based on the travelling time, length of distance, number of turns in order to provide the most suitable paths for the user.

VI. Results And Disscussion

The primary aims of this paper are monitoring the user's position by using the data from accident detection system embedded in user's phone, determining the status of accident with the sensors' values and classifying the level of accident, diminishing the rate of receiving false alert messages from the users and preventing the accident victims from the death by providing the timely medical treatment at accident location.

The Motion Sensing Method assists to obtain the values from the accelerometers and gyroscopes sensors and then a prompt estimation can be performed for the probability of accident. In some cases, it is possible to receive the values

exceeding the accident threshold limit if the smartphone may be tilted or dropped from its dock. To lessen the inaccuracy results in accident validation process, the Modern Positioning Method is put into operation by collecting the newest value of GPS and, comparing such value with its closest previous GPS values once the system identifies the status of accident.

As stated in section IV(b), the Difference Angel Method can expose the direction angel of the user's vehicle while GPS system can only provide its latitude and longitude values. Despite having the sensors' value higher than the accident threshold, it is assumed the status of vehicle is under control if the car keeps moving towards the same direction when the latest value of GPS is not different from its closest previous value. To classify the accident levels for minor, major and critical defection, the values of accelerometers and gyroscopes are analyzed together with the GPS track angles results. As illustrated in Figure 5, the accident level is regarded as minor accident if the predicted threshold values are low and the GPS track angle result is either low or medium, or the Predict Threshold Values are medium and the GPS track angle result is low. Besides, the accident level is specified as critical when the predict threshold values are shown as medium and the GPS track angles result is stated as High, or the GPS track angle results are either medium or high while the predict threshold value is high. On the other hand, the accident level is denoted as major when both predict threshold values and GPS track angles result are indicated as either low or medium or high. The minor defect level is nominated by accident detection system as an active emergency case while the major and critical levels are determined as the significant damage and the occurrence of multiple fatalities respectively. The system analyzes the data and then, retrieves the most updated contact points of rescue services that are shown in the created Polygon.

		GPS Track Angles Result		
		Low	Medium	High
Predict Threshold Values	High	Major	Critical	Critical
	Medium	Minor	Major	Critical
	Low	Minor	Minor	Major

Fig 5. Classification of the Accident Level

To ensure the accurate result of the user's position, Modern Positioning Method assist to measure the time difference of the arrival of numerous signals from the user's mobile device. Those signals will be received by the available networks and then the location of the source of signal can be computed by applying the signal data and the time, distance and velocity relationship. Then, a confirmation message will be delivered to the users to verify the status of accident when the sensors' values surpass the predefined threshold values. The system waits for at most (20) seconds to get the validation reply from the user.

When the waiting time of (20) seconds is over, the systems automatically generate the visual polygon with the assistance of Geofencing technology nearby the accident scene even if the user cannot reply the accident confirmation message. As a result of the visualized features of Geofence and the application of Object Detection in Fence Algorithm, location of accident and the closest rescue service are quickly identified, and the accident detection system restores all the contacts of rescue services inside the Polygon from the updated rescue service dataset to perform the needed actions on time.

In order to have the better functioning of the sensors and receive the perfect outcomes, the mobile phone has to dock in the automobile throughout the trip. It is important to collect the movement values in time, and the standard value is marked as 5g. When the value of X axis is exceeding or falling behind the values of Y and Z axes within 0.6 second, it is noted that the accident occurs. If the X axis' value is remarkably larger than the values of other two axes, Y and Z, it can be considered as the critical accident happens.

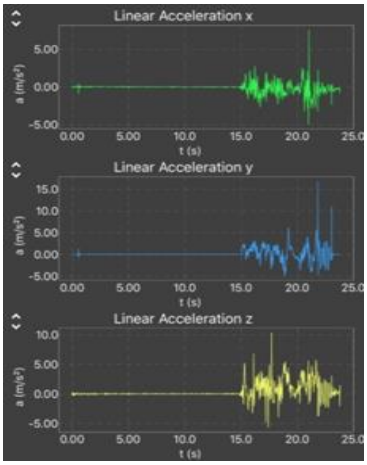

Fig 6. Display Accident Case of Vehicle

Figure 6 shows that the 3-Axes accelerometer is used to evaluate the sensors' accelerations while the car is rolling or spinning without any control, and the value of X-axis (acceleration) goes beyond the standard limits (-5g and +5g). The exclusive client-server architecture is needed to gather and update the live information on expressway in database server, so the different users can retrieve the data and are ensured about the current situations. The operation of this system is easy to use for everyone and, the users are encouraged to provide their personal and other information at the beginning of every trip on expressway.

In figure 7(a), it illustrates that the users must do the registration by providing their personal and vehicle information before starting the trip. This registration process is a compulsory for every user as it is needed to organize some essential procedures such as preparing the blood in need for the accident victims.

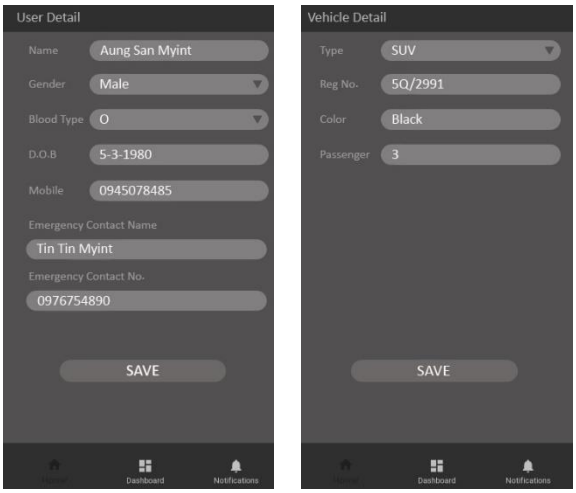

Fig 7(a). User and Vehicle Data Registration

All users and vehicles information are stored in database and, can be retrieved anytime. Figure 7(b) demonstrates the accident message received by the nearest rescue services from the place of accident. The message contains the list of personal and vehicle information of accident victims at the time period. The most recent accident is displayed at the top.

Fig 7(b). Accurate Accident Information of System

VII. Conclusion

Once the current rescue procedures in used are examined, it is observed that there are some vulnerabilities in existing accident detection techniques or methods such as speed limitation, high possibility of false accident signals received, the unavailability of predefined dataset for analyzing purpose, and non-automated controls to update database.

The accident detection system in this paper is able to operate with the different trained datasets and Google application programming interfaces (APIs), so the vulnerabilities mentioned in above similar researches may be worked out. After upholding the well-trained datasets in system, the current user's status on expressway is kept tracing and updating continuously in the database so that the system can retrieve the data anytime to confirm the accident condition. Besides, with the assistance of Geofencing and the Google APIs, the precise place of accident will be traced without any delay and then, the closest rescue services will be identified and sent the message to deliver the timely medical assistances.

Whether the user is unconscious or not, the system will wait for a certain time duration and then automatically send the alert information to the nearest rescue service via Geofencing for the medical and other arrangements. In addition, the most updated user information will be attainable from the system's database server in order to confirm the status of accident because the server is continuously synchronizing with the user's smartphone even the phone is power off.

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