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Research paper

Vehicle tracking and accident detection system using accelerometer

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Abstract

Nowadays road accidents are a major issue of concern. Even with so many modern devices present in the field of vehicle design, road lane design and heavy traffic control accidents do occur at a large scale. In most accidents, people lose their lives as no medical facility is reached there at proper time and place. To reduce this risk factor accident detection system leads important role. Any kind of accident detected is automatically sent as an alert to the required destination. Accident detection device installed in a vehicles when meets with an accident will send SMS/ messages to the pre-install numbers of the drivers family members, police station, ambulance and nearest hospital. This automated tracking system can be useful for tracking and detecting the exact position of any automobile, which has met with a collision by using Global Positioning System (GPS) and sensors.

Keywords: *Accident Detection Device; Accelerometer; Embedded System; Global Positioning System (GPS); Vehicle Tracking and Sensors.*

1. Introduction

In the current world, we can observe that the road accidents are occurring frequently due to various reasons like sudden manhole or cross vehicle who did not follow the signals. Sometimes, even though we are driving carefully, accidents will occur may be because of behind vehicles or front vehicle so to track these issues without driver attention we need a vehicle tracking system.
As per the statistics provided by the Association for Safe International Road Travel (ASIRT), around 1.25 million individuals wedged in road crashes every year, 20-50 million square measure hors de combat or disabled. These vehicle collisions square measure cost accounting over $518B word wide, cost accounting individual states from 1-2% of their yearly value. The challenges imposed to local PSOs in saving human lives resulting from vehicles accidents have become a crucial concern due to the huge aforementioned number of departed people. As far as many injured could lose their lives, and since no on-site medical assistance has been provided promptly as a result of: (1) late accident reporting, (2) inaccurate geographic location, and (3) lack of injured medical information, the need for automated and intelligent mobile solution tackling this burden becomes a must.
The current existing solutions that provide assistance to passengers in case of vehicle accident occurrence are mainly concerned with user interaction after the incident happened.
Those mobile solutions require that the injured must launch the app and request help manually and that would not be possible if he/she is under critical or serious non-vital situation. The situation becomes even worse if passengers went under unconscious state.

2. Related work

This section overlooks similar existing solutions and examines their advantages and disadvantages. Auto Accident App, developed by PlatinumPeak LLC [3], could be a portable application to supply free, help to accident victims. It provides one-button access to emergency personnel and piecemeal steerage through the data gathering method to confirm that no important information or proof is incomprehensible. The most disadvantage is that it serves solely as a variety of manual reportage regarding the accident once it's being taken place. Hence, it doesn't extremely give any variety of rescue for the passengers. Motor vehicle Accident App, developed by the white potato Battista [4], is a useful application for people WHO ordinarily or maybe sometimes realize themselves behind the wheel of a vehicle. It options time saving forms that enable users to obviously collect accident data. Not being machine-driven is taken into account a disadvantage of this application.
Accident Report, developed by Dr. Apps [5], enables to produce associate degree accident report (a PDF file) during a straightforward and arranged means, PRN by insurance firms and therefore the police, while not missing vital details throughout associate degree accident scenario. The most disadvantage of this app is that it focuses on reportage and doesn't give any sense of rescue. All the solutions lack an automatic good approach to accident detection, reportage and navigation.

3. Method

In this section, we elucidate our proposed system at a high-level scope. The system is composed of the following phases:

a) Vehicle registration and preparation
b) Passengers 'registration
c) Monitoring accidents through a web interface located in the PSO headquarter.

3.1. Vehicle registration and preparation

This phase deals with the process of vehicle registration. The vehicle's owner must prepare the vehicle for this system by installing the IoT device. After installing the device, the owner gives the Vehicle ID to the operator responsible for vehicles registration in the headquarters' database. This would lead the PSO to recognize that the registered vehicle satisfies the pre-conditions to be integrated in the system.
The IoT device encompasses four modular components: shock sensor, GPS, NFC reader, and cellular IoT. Those combined modules altogether spontaneously notify the rescue organization headquarter whenever an accident takes place, pinpoint the exact location, and recognize the passengers inside the vehicle on the headquarter map. The triggered sensor signal reports the vehicle's identifier along with the accident's location which appear on a web-based interface in the rescue center. This enables the rescue teams to respond immediately.

3.2. Passengers' registration

a) The mobile application aims at providing a one-time only registration form for passengers' personal data. The personal data include: (a) Full name
b) Blood type
c) Phone number
d) Email
e) Medical history
f) Date of birth
g) Reference phone number. The whole record of passenger's information is uploaded to the headquarters' database once the registration process is complete.

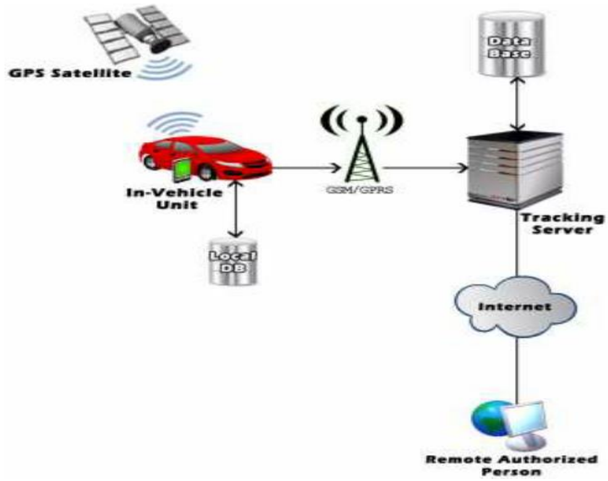

Fig. 1: Vehicle Tracking System.

In this section, we give some preliminary notations, define several key concepts related to the paper, and formulate the problem to be handled in this paper.

3.3. Accelerometer

An accelerometer could be a device that measures correct acceleration. Correct acceleration, being the acceleration (or rate of modification of velocity) of a body in its own instant rest frame, isn't a similar as coordinate acceleration, being the acceleration during a fastened system. to Illustrate, AN measuring system at rest on the surface of the world can live AN acceleration because of Earth's gravity, straight upwards (by definition) of g ≈ 9.81 m/s2. in contrast, accelerometers in free fall (falling toward the middle of the world at a rate of regarding nine.81 m/s2) can live zero.

3.4. GPS

Stands for "Global Positioning System", GPS could be a satellite navigation system wont to confirm the bottom position of associate object. GPS technology was initial employed by the us military within the Sixties and dilated into civilian use over following few decades. Today, GPS receivers square measure enclosed in several business merchandise, admire vehicles, smartphones, exercise watches, and GIS devices. The GPS system includes twenty four satellites deployed in house concerning 12,000 miles (19,300 kilometers) on top of the surface. They orbit the world once each twelve hours at a very quick pace of roughly 7,000 miles per hour (11,200 kilometers per hour). The satellites square measure equally displayed in order that four satellites square measure accessible via direct line-of-sight from anyplace on the world. A GPS [32] receiver combines the broadcasts from multiple satellites to calculate its precise position employing a method known as triangulation. 3 satellites square measure needed so as to work out a receiver's location, tho' a affiliation to four satellites is good since it provides bigger accuracy. In order for a GPS device to figure properly, it should initial establish an affiliation to the specified range of satellites. This method will take anyplace from a number of seconds to a number of minutes, reckoning on the strength of the receiver. Let's say, a car's GPS unit can usually establish a GPS affiliation quicker than the receiver during a watch or smartphone.
The GPS provides very important positioning capabilities to military, civil, and business users around the world. The US government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.
Monitoring Accidents: When a passenger gets in the car and taps the Near Field Communication (NFC) handheld device(mobile phone), the passenger's ID and the vehicle's ID are transmitted and stored into the headquarters' database (see Fig. 1). Consequently, the database server establishes the mapping between the pre-registered personal information and the passenger's ID. As a result, the headquarter can recognize exactly the information of the passenger inside the vehicle. This process can be applied to all passengers in the car. The IoT Bluetooth Low Energy (BLE) communication protocol can be used as an alternative to NFC, to signal the presence of the passenger inside the vehicle.

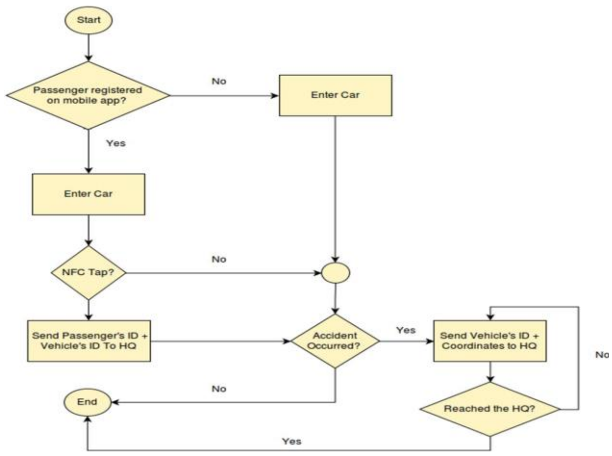

Fig. 2: System Flowchart.

In case of vehicle's accident, the airbag, or any shock detection mechanism triggers the shock sensor and consequently a Hypertext Transfer Protocol (HTTP) request alerting the occurrence of an accident and its geographical location is sent to the server. Since the server has previously recognized the passengers inside the vehicle, it can now spot the passengers that are in danger. A rescue team can then be sent immediately to the acknowledged location carrying out appropriate medical support since premedical info have already been identified by headquarters' operator.

4. Design and architecture

The below system architecture is the conceptual model that defines the structure, behavior, and more views of our proposed system.

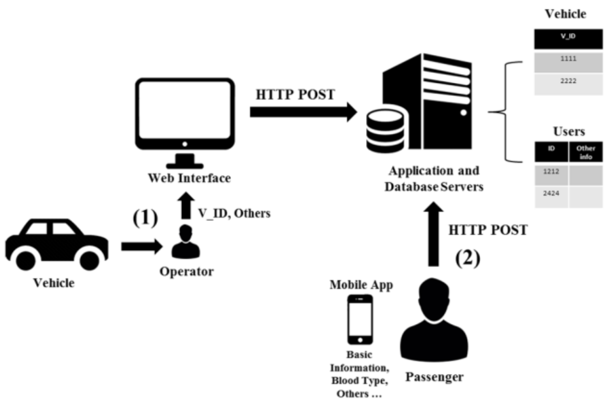

Fig. 3: Registration Phase Architectural Diagram.

The preparation/registration phase discussed earlier is illustrated in detail in Fig 2. The operator registers the vehicle using its vehicle ID through a web interface connected to the database server. As a result, the Vehicle table in the database now comprises records pertaining to all registered vehicles.
On the other hand, the passenger registers himself/herself on the server through the corresponding mobile interface. This would make a passenger eligible to get into any equipped vehicle and benefit from the rescue facilities provided by the system.

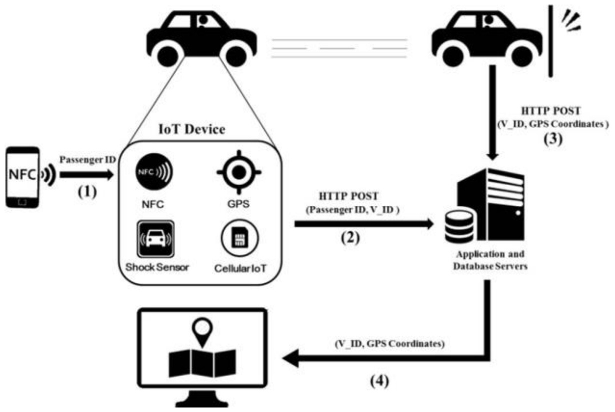

Fig. 4: Monitoring Phase Architectural Diagram.

The monitoring phase discussed in section III is illustrated in Fig 3. When the user taps the NFC enabled device (mobile phone) to the IoT node, an HTTP request holding the passenger's ID and the vehicle's ID, is sent through the IoT cellular network to the application/database servers. If a passenger decides to leave the car, he must tap again the NFC enabled device for the record to be removed from the database. Another alternative could be to store the information locally in a memory, thus, reducing the number of transactions on the server.
On the server side, a table containing the current trips is maintained. Each trip consists of its passengers and the vehicle's ID. In case of accident, another HTTP request containing the vehicle's ID and the GPS coordinates (longitude and latitude) is sent to the server in which all records' attributes are stored in the database and inserted to an XML file simultaneously
(See Fig. 4).

Technically, the webpage is reading asynchronously from the XML file the child entries "marker", and updating the map without having to refresh the page repetitively.

```
-<markers>
  <marker status="Pending" car_id="263463_0" lat="33.88497" lng="35.52343"/>
</markers>
```

Fig. 5: XML File Containing Current Accidents.

While reading the XML file, a pin pops up on the map indicating the location of the accident.
When the operator browses the map, locates and clicks on the pin, a popup window is displayed, showing all passengers' information. This allows the rescue team to prepare the required medication, treatments, and toolkits beforehand.

4.1. Vehicle tracking and accident detection system

Tracking System [17] is the system which track vehicle current location using global positioning system (GPS). When the accident will occurred, then the system will direct send the accident alert message along with location details of the accidental vehicle to emergency dispatch sever further it will send that alert message to the nearby ambulance so that it will go to that location. If we use, these kind of devices, we can reduce the death rate lead by road collisions.

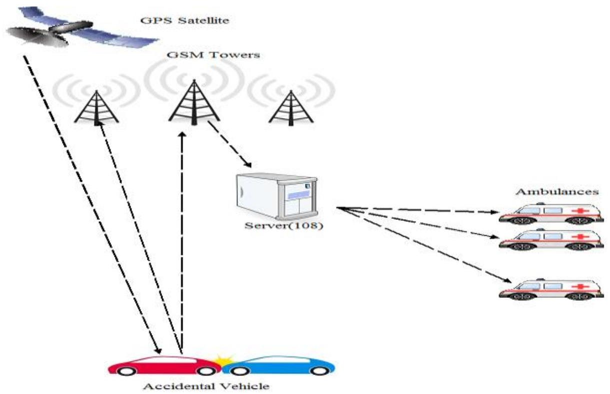

Fig. 6: System Architecture.

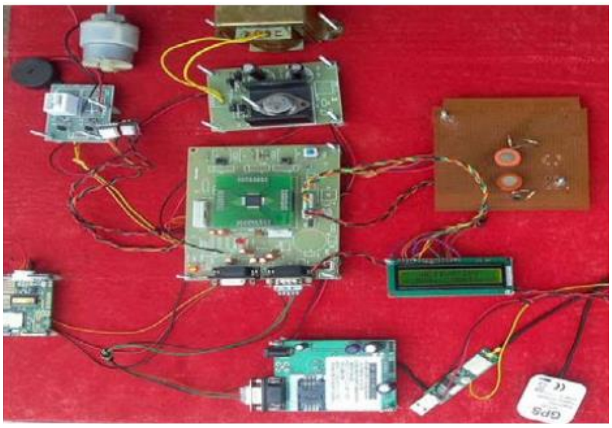

Fig. 7: Working Model.

5. Implementation

Components:

- temperature sensor LM35
- Accelerometer sensor
- Voltage regulator
- LCD
- Motor
- ARM7 –LPC 2148 microcontroller
- GPA and GSM

- Keil software
- Embedded c

5.1. Hardware components

In our implementation we have used an IoT device containing different components and modules as well as communications capability. The main components of this device are:

5.1.1. Shock sensor

Shock sensor [31] may be integrated in varied ways in which to match the vehicle requirements. It may be activated by vibration or triggered by extremely effective safety system airbag. This airbag system contains many elements and mechanism that all work along to confirm the physical integrity of the passengers to the very best degree [6]. The sensitivity of the used device is adjusted to fulfill the standards adopted in safety airbag systems.

5.1.2. Global positioning system (GPS)

GPS navigation is a component that accurately calculates geographical location by receiving information from GPS satellites [7]. The SKM53 GPS module device is used to send to server the exact vehicle location.

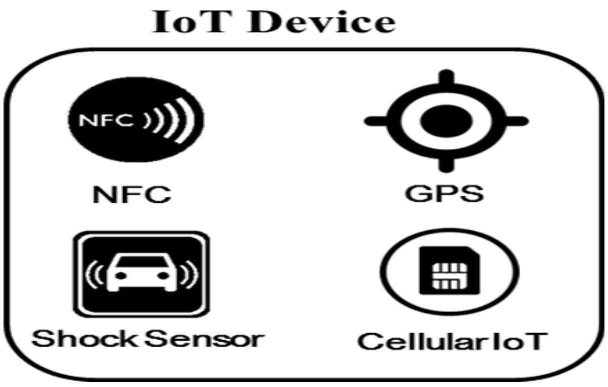

Fig. 8: IOT Device Components.

5.1.3. NFC reader

Near field communication (NFC) [27] is a set of communication protocols that enable two electronic devices, one of which is usually a portable device that is used to identify each passenger by detecting his/her ID. Then the IoT device sends and matches this ID with the corresponding remote database entry.

5.1.4. Cellular IOT

It is required to implement cellular IoT 3rd Generation [27]
Partnership Project (3GPP) technologies: Extended coverage Global System for Mobile communication (ECGSM), Long Term Evolution (LTE), Long Term Evolution Machine to Machine LTE-M, and the new radio access technology Narrowband IoT (NB-IoT).
As for the higher layers in the IoT protocol stack, the emerged protocols, the Constrained Application Protocol (CoAP) over User Datagram Protocol (UDP), Datagram Transport Layer Security (DTLS) can be used to overcome the limitations of the IoT devices' constraints.
Our system uses the cellular 3G module to establish all kind of wireless communications from and to the server.

5.2. Software components

The mobile application is built using Android TM Operating System. Hypertext Preprocessor (PHP) is used for server-side scripting, Raspberry Pi open-source prototyping platform for data and signal processing. In addition, a near field communication (NFC) component is used to read the user's data from the mobile. The Raspberry Pi board was programmed using the Python programming language.
A GPS component is used to send the exact location of the vehicle that had the accident. Finally, MySQL is used as the Database Management System (DBMS). Navigation
In our proposed system, a navigation mechanism is implemented using the Haversine function to determine all distances between the accident location and all wide spread rescue teams. The Haversine is a vital formula in navigation, gives great-circle distances between two coordinates on a sphere from their longitudes and latitudes [10].

```
Require: Points – A list of points identifying the location of rescue teams
Require: AccPoint – A point representing the accident's location
Output: Sorted list of distances in ascending order
  DistanceList ← empty
  i ← 0
  for CurPoint in Points do
    DistanceList { i++} ← Haversine (AccPoint, CurPoint )
  end for
  Sort (DistanceList)
  return DistanceList
```

Fig. 9: Pseudocode for Determining the Nearest Point.

Fig. 9 illustrates the rescue teams' distributions and then calculated distances to accident location.

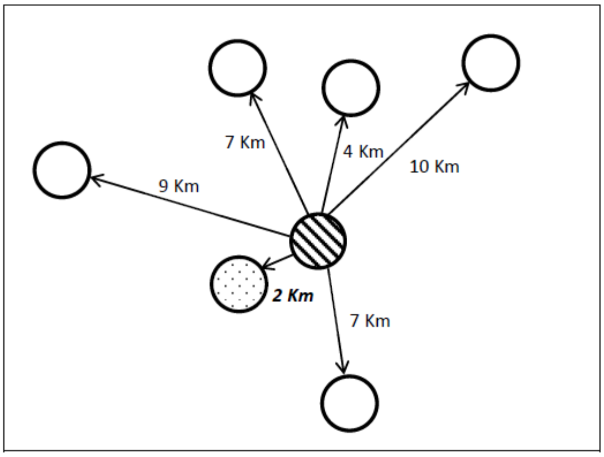

Fig. 10: Points Distribution Example Scenario.

For any two coordinates on a sphere, the Haversine of the central angle between them is given by

$$\mathrm{hav}\left(\frac{d}{r}\right) = \mathrm{hav}(\varphi_2 - \varphi_1) + \cos(\varphi_1)\cos(\varphi_2)\,\mathrm{hav}(\lambda_2 - \lambda_1)$$

where
hav is the Haversine function:

$$\mathrm{hav}(\theta) = \sin^2\left(\frac{\theta}{2}\right) = \frac{1-\cos(\theta)}{2}$$

d is the distance between the two points (along a great circle of the sphere; see spherical distance), r is the radius of the sphere, φ1, φ2: latitude of point 1 and latitude of point 2, in radians λ1, λ2: longitude of point 1 and longitude of point 2, in radians. The list of all calculated distances is sorted in ascending order to determine the second nearest rescue team whenever the former team is not available. (see Fig. 10) A push notification of the accident's location is sent to the closest available rescue team which can now use the Google Map service to determine the shortest route to destination.

6. Results

This section shows a simulation of some important features implemented in our system. (1) On the headquarter side, Fig.6 illustrates a pin instructing the occurrence of an accident.

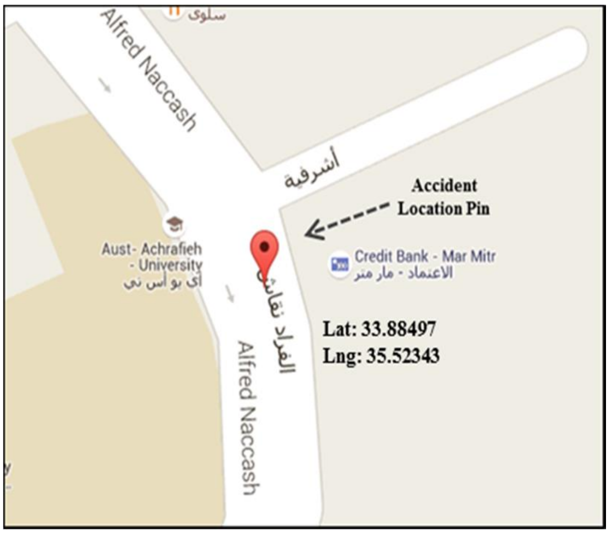

Fig. 11: Detecting Accident.

The map also shows the geographical coordinates (longitude, latitude) of the accident location. (2) When the operator clicks on the pin, a popup window is displayed, showing all passengers' information. This allows the rescue team to prepare the required medication, treatments, and tool kits beforehand as shown in Fig. 11.

Passengers Information

+ Coming

Name	Age	Phone	Blood Type	Email	Allergy
Elie Kfoury	25	+961123456	A+	ekfoury@aust.edu.lb	None
Elie Nasr	45	+961987654	O+	enasr@aust.edu.lb	None
David Khoury	50	+961456123	B	dkhoury@aust.edu.lb	None

Fig. 12: List of Passengers and their Information.

(3) In Fig. 12, when the operator press on the "+ Coming" button, a new popup windows is displayed showing a sorted list of all rescue teams along with the calculated distances to accident location (see Fig. 10).

Team Number	Location	Distance from Accident
Team 1	Ashrafieh	02 KM
Team 3	Hazmieh	05 KM
Team 2	Broumana	08 KM

Fig. 13: List of PSO's Rescue Teams.

(4) In Fig. 13, when the operator select "Team 1", a push notification is sent instructing Team 1 leader to route to the accident location as shown in Fig. 11.

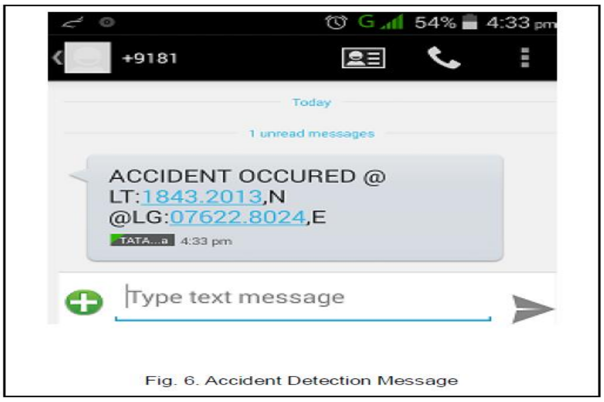

Fig. 14: Accident's Location Sent to the Rescue Team Leader.

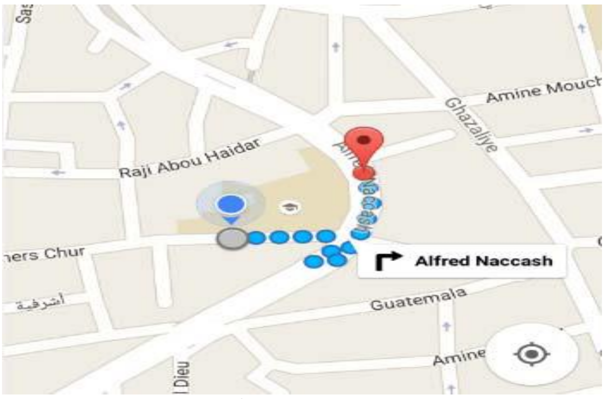

Fig. 15: Routing from Team Location to Accident.

Fig. 15 shows the track that the team must traverse to reach the accident location.

6.1. Performance

The load on the server is not considered as enormous as the number of transactions is limited to the number of accidents during a period of time. Therefore, the number of reporting is not immense comparing to any normal application in the market. In the alternative where the passenger information is stored in the car, the number of transactions will be even lower. Regarding faulty alarms delivered by the sensor, at least three alarms should be sent to confirm the accident. If one alarm is sent, then it is considered as faulty alarm.

7. Conclusion and future work

In this paper, we proposed and implemented an IoT system which may help the community decreasing the death rates resulting from vehicles accidents. Results showed that this solution provided many advantages compared to traditional systems, namely, minimizing injured passengers interaction providing basic medical information to rescue teams recognizing exact and accurate accidents locations, and facilitating the routing process. The IoT device keeps sending continuous notification of crash occurrence until it makes sure its reception by the headquarter. Accident detection device installed in a vehicles when meets with an accident will send SMS/ messages to the pre-install numbers of the drivers family members, police station, ambulance and nearest hospital. This embedded system is useful for tracking and retrieving the exact position of any vehicle which has met with an accident by using Global Positioning System (GPS) and sensors. Our future vision is to enhance the system and push forward toward integrating it into each vehicle during the manufacturing phase. Also, this system could be managed to get passenger information using a primary key like the Social Security Number (SSN) from a governmental centralized database.

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