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REDUCING THE TIME TO GET EMERGENCY ASSISTANCE FOR ACCIDENT VEHICLES ON THE ROAD THROUGH AN INTELLIGENT TRANSPORTATION SYSTEM

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ABSTRACT:

Intelligent Transportation Systems (ITS) is one of the main components of a smart city. ITS have several purposes including the increase of the safety and comfort of the passengers and the reduction of the road accidents. ITS can enhance safety in three modes before, within and after the collision by preventing accident via assistive system, sensing the collision situation and calculating the time of the collision and providing the emergency response in a timely manner. The main objective of this paper is related to the smart transportation services which can be provided at the time of the collision and after the accident. After the accident, it takes several minutes to hours for the person to contact the emergency department. If an accident takes place for a vehicle in a remote area, this time increases and that may cause the loss of life. In addition, determination of the exact location of the accident is difficult by the emergency centres. That leads to the possibility of erroneous responder act in dispatching the rescue team from the nearest hospital. A new assistive intelligent system is designed in this regard that includes both software and hardware units. Hardware unit is used as an On-Board Unit (OBU), which consists of GPS, GPRS and gyroscope modules. Once OBU detects the accident, a notification system designed and connected to OBU will sent an alarm to the server. The distance to the nearest emergency center is calculated using Dijkstra algorithm. Then the server sends a request for assistance to the nearest emergency centre. The proposed system is developed and tested at local laboratory conditions. The results show that this system can reduce Ambulance Arrival Time (AAT). The preliminary results and architecture of the system have been presented. The inclination angle determined by the proposed system along with the car position identified by the installed GPS sensor assists the crash/accident warning part of the system to send a help request to the nearest road emergency centre. These results verified that the probability of having a remote and smart car crash/accident decision support system using the proposed system has been improved compared to that of the existing systems.

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1. INTRODUCTION

According to World Health Organization (WHO), about 1.35 million people in the world have been dead in car accidents in 2018; in other words, every 25 seconds one person is killed in a car accident. This statistic in Iran was 15932 persons in 2018. One of the components of a smart city is the Intelligent Transportation Systems (ITS), which has several purposes, including increasing the safety and comfort of passengers and reducing road accidents. ITS can affect safety in three modes. The first mode is related to systems and platforms to prevent the accidents. The second mode is related to the time of the accident and the third mode refers to systems that begin after the accident. The main objective of this paper is related to the smart transportation services which can be provided at the time of the collision and after the accident. After the accident, it takes several minutes to hours for the person to contact the emergency department. If an accident takes place for a vehicle in a remote area, this time increases and that may cause the loss of life. It will be even worse during the night time. In addition, finding the exact location of the place that accident happens is difficult to be identified by the emergency centres. That leads to the possibility of erroneous responder act in sending the rescue team from the nearest hospital. A significant parameter of survival rates after an accident is the time between the accident occurrence and when ambulance is arrived to the accident location. By reducing the Ambulance Arrival Time (AAT), a significant number of lives can be saved.

A new assistive intelligent system is designed consisting of hardware and software components for intelligent accident detection and accurate location of the accident. The system is designed to send a request for assistance to the nearest emergency center. An intelligent system for emergency alarm would detect and analyse the dangerous events, and notify the emergency center for immediate action. There are few such systems available, most of them are costly or may require human's action. Also, in rollover accidents, people (driver or other persons in the car) cannot send a notification to emergency center (Acharya et al., 2008). For detecting the accident, spatio-temporal and gyroscope data are used. The hardware deigned in this study consists of GPS, gyroscope and SIM808 modules.

2. BACKGROUND

Smartphone and accident detection system are used to send a notification to the nearest rescue centers and friends. The attached accelerometer in the vehicle sense the tilt of the vehicle and the heartbeat sensor on the user's body senses the abnormality of the heartbeat to detect the occurrence of the accident. Thus, the system will make a decision and sends the information to the smartphone connected to the accelerometer and heartbeat sensor through Bluetooth. The smartphone will send a message to the appropriate medical centers (Kattukkaran et al., 2017).The crashed car has been observed using vibration sensor and the accident is reported by the microcontroller to the control section and then the nearby ambulance is dispatched from the control section (Vignesh, 2017). A system was implemented about such a facility in vehicles to save our souls (SOS) support which had normal cameras producing an unclear view. The proposed system improved the efficiency of accident report with the help of a fisheye lens camera which produces more detailed view inside the vehicle. Using the fisheye lens camera, sensors and SIM908-C the emergency helpers will get the detailed report about the accident immediately (Manoharan et al., 2012). A novel approach is proposed based on integrating accelerator, alcohol sensor and ultrasonic. Thanks to these sensors, severity of the accident, the level of alcohol inside the car and nearest obstacles were detected. Then a short message service (SMS) was sent to an authorized person (Ingle and Engineering, 2014). An architecture for detecting car accidents based on smartphones was developed using accelerometers, and GPS sensors to provide a "black box". This architecture shows how smartphones in a wireless mobile sensor network could capture the streams of data about the accident events (Thompson et al., 2010). A GPS based system was designed and implemented to detect an accident. Also, to provide a clear path for the ambulance, traffic light signals in the way of the ambulance were controlled via radio frequency (RF) communication. This system can monitor the vital parameters like temperature and pulse rate and conveys them to the concerned hospital (Manasia et al., 2016). The controlling system was proposed for automatically controlling the path of the ambulance from the detected spot to the hospital. Wireless technologies are used for information transfer. When the ambulance reaches the traffic junction, the encoder converts the serial data into parallel data when it passes from the transmitter to the receiver. If the signal is red, it changes to green automatically (Chowdhury et al., 2015).

The accuracy in this research is more than that of the systems that use mobile applications for detecting accidents. Also, the time is reduced for connection between the modules due to using an integrated system. In fact, all the sensors are connected together in a physical board without using Bluetooth or other remote connection devices.

3. SYSTEM DESIGN AND ARCHITECTURE

Systems that are used in ITS are usually made up by hardware and software components. The main parts of the hardware are GPS, Sim808, GY-521 and microcontroller. Figure 1 represents the process of detecting accident and dispatching an ambulance from the nearest emergency center. The hardware components may be installed on a vehicle or on the roadside. The components that are installed inside the vehicle are called OBUs. For this research, a unique OBU has been designed and manufactured. Figure 2 illustrates components of the designed board to detect the deviation of the vehicle from the gyroscope at the time of the car accident.

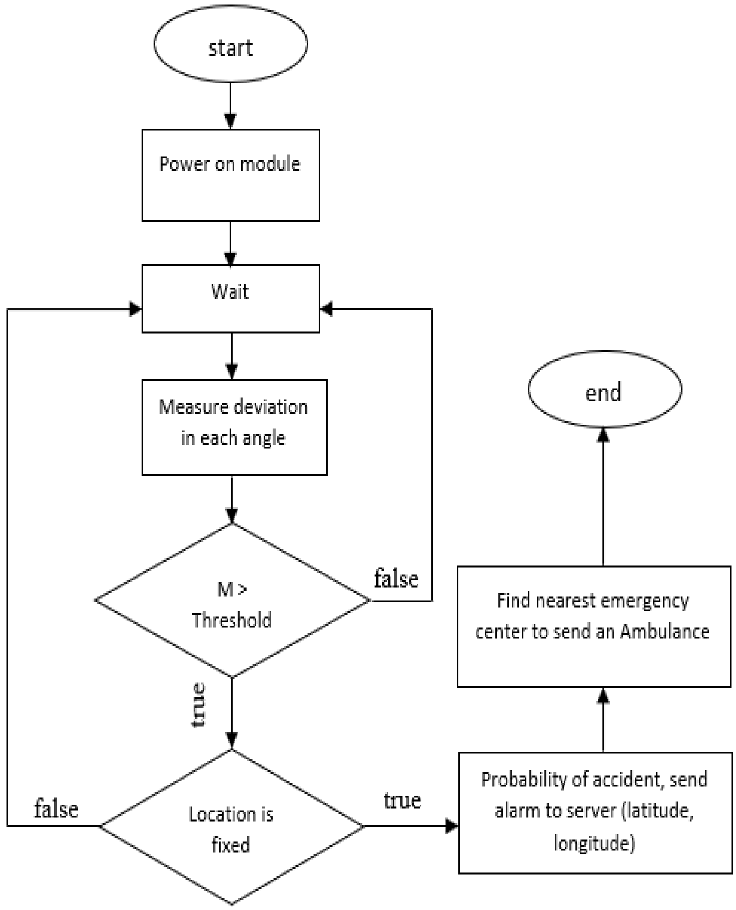


Figure 1. Diagram activity of the proposed assistive accident detection system.

There are various manufacturing technologies for gyroscope modules such as fiber optic and mechanical technology, Laser ring, micro electro mechanical system and Micro Electro Mechanical System (MEMS). The module used in this research and connected to the original board is called GY521. Its manufacturing technology is MEMS. This technology is based on physical Foucault Pendulum phenomenon and has electro mechanical oscillating components. It helps to identify rotation. The GY521 module is a 3-axis gyroscope with an internal accelerometer manufactured based on the MPU6050. The MPU6050 has six analogue-to-digital data converters with a precision of 16 bits. The method for communication of this module with the desired range is the i2c protocol. The MPU6050's working voltage is between 2.37 V-4.46 V (Figure 2).

3.1 Modules in OBU

3.1.1 Rotation detector (GY-521)

GY-521 includes three axes gyroscopes with sensitivity up to 131, the least valuable data per degree in seconds LSBs/dps with four measuring ranges $\pm$250, $\pm$500, $\pm$1000 and $\pm$ 2000 degrees per second. The three axes accelerometers with programmable range for 4 intervals $\pm$16g, $\pm$8g, $\pm$4g, $\pm$2g exist. Digital motion processing engine (DMP) is employed with the ability to execute complex motion fusion algorithm sensor time synchronization and motion type detection. The internal algorithms are required for the bios at run-time and also the ability to calibrate the compass without the need for user intervention.

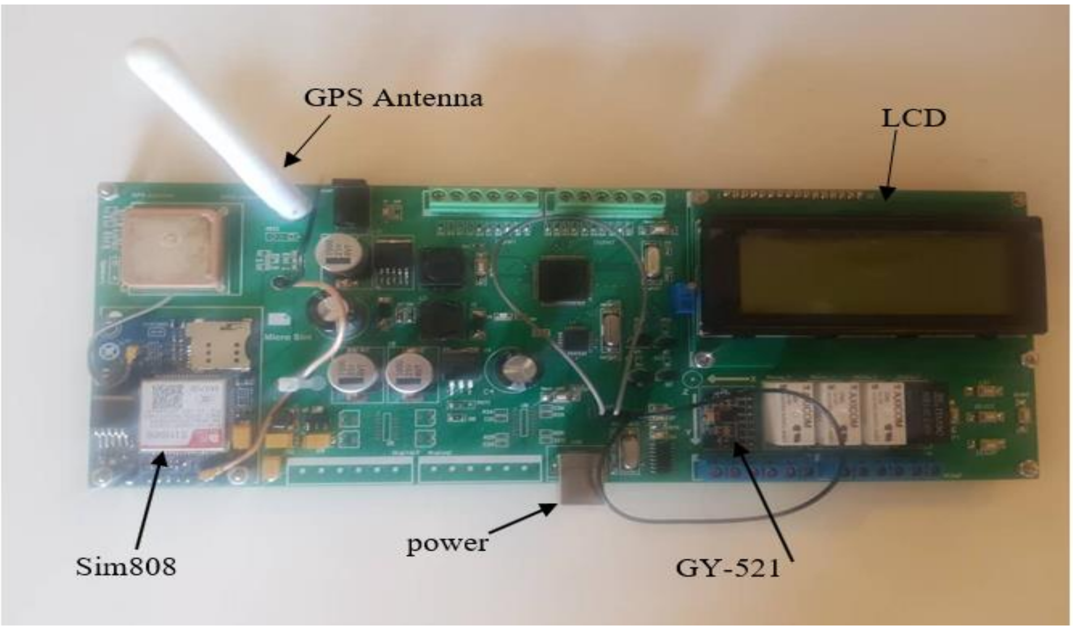
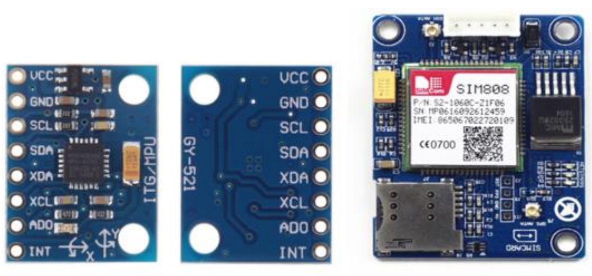


Figure 2. The components of the main board including LCD, GPS, Sim808, Power, and GY-521

The internal sensor thermometer has been implemented with digital output with programmable intervals with the ability to support motion detection such as shock, abrupt movement, up and down motion, free fall, high acceleration motion, motionless as well as to detect shocks and to detect intermittent vibration. Internal timing circuit is established with frequency variations of 1% in changes to the total amount of working temperature range. Mechanical shock capacity up to 10,000. chip: MPU-6050. Voltage: 3.5 Volts (because of the presence of a voltage regulator on the range, use a voltage of 5 Volts directly) are considered (Figure 3a).



a b

Figure 3. The main components of the designed system for detection of the car accidents. a) GY-521 module b) Sim808

3.1.2 Sim808

Another module is used to locate and send an alert to the nearest rescue center is called Sim808 (Figure 3b). This device is installed on the vehicle. Through the sudden changes in acceleration as well as angle variation along the x and y axes, the probability of an accident is determined and the request is sent to the emergency centre, accordingly. The software component of this platform includes a server, a database and a program for the rescue centres. In the database there are some information about the rescue centres such as their exact coordinates. The rescue centres can view the coordinates of the accident on the map (Figure 7). The position of the crashed car is sent to the server of the proposed system. Then the nearest rescue centre is determined in the server using Dijkstra algorithm. A notification is dispatched to the nearest road rescue centre to assist the crashed car. There are four rules to detect dangerous events under the circumstances:

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$if\ \Delta\theta >$ Threshold and $\Delta R < r \rightarrow$ danger
$if\ \Delta\theta <$ Threshold and $\Delta R > r \rightarrow$ not important
$if\ \Delta\theta <$ Threshold and $\Delta R < r \rightarrow$ car is stopped or crash occurred without rollover
$if\ \Delta\theta >$ Threshold and $\Delta R > r \rightarrow$ not important

Where $\Delta\theta$ is the inclination angle and the threshold is determined as an optional value to detect rollover status. ΔR is car displacing which is determined by GPS and r is the minimum displacement that can be detected by GPS.

4. IMPLEMENTATION AND RESULT

The locations of all emergency centers are stored in the database (DB). The DB was developed using MongoDB. Also, the server side was developed using Nodejs which is compatible with MongoDB. Google Map API was used for the base map and also represents the location of the accident. For developing this system, C++ is used for OBU programming and JavaScript is used for the server and MongoDB.

Whenever an accident of the vehicle occurs, then the OBU sends a message with the information of the accident location and time to the server. Then the server calculates the nearest emergency center using Dijkstra algorithm. After that, server will send a notification to the mentioned emergency center. Thus, the system shows the location of vehicle where the accident has been occurred with the help of the GPS module. As real rollover accident was not accessible in our research, the proposed system was developed and tested at local laboratory conditions.

For evaluating the system, a parameter is used as a risk of death (ROD) after accident which depends on 4 parameters. Time to contact emergency center and AAT are two major parameters (Manoharan et al., 2012). Also, severity of accident and the location of accident are considerable parameters in the ROD (Equation 1). ROD_2 represents risk when our system is used and ROD_1 belongs to a risk in the usual situation. Since, severity is the same in the both types of ROD, the performance of system is calculated using Equation 2 (Manoharan et al., 2012).

$$ROD_i = f(S, \alpha_i, AAT_i, \beta_i) \qquad (1)$$

where S is severity, α is time to contact emergency center, AAT is ambulance arrival time and β is erroneous of accident's location.

$$Performance = \frac{ROD1}{ROD2} \simeq \frac{\alpha_1 . AAT_1 . \beta_1}{\alpha_2 . AAT_2 . \beta_2} \qquad (2)$$

In this research, to establish a connection between the server and client, RESTful application program interfaces (APIs) are used as web services. REST stands for the representational state transfer. This type of interface uses 4 methods to manipulate server side. These methods use HTTP requests (GET, PUT, POST, and DELETE). A RESTful web service is based on the REST technology (Figure 4).

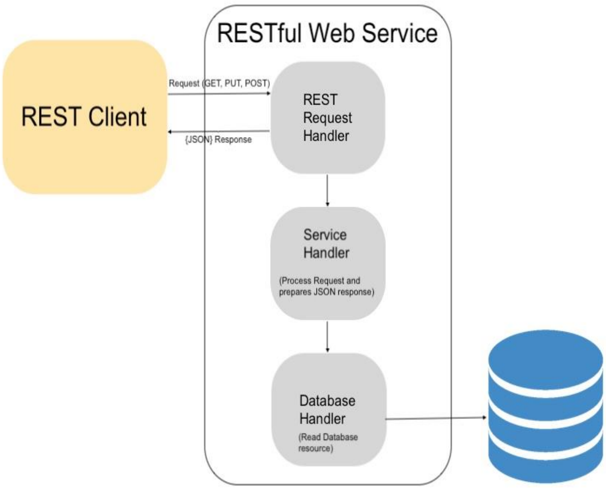

Figure 4: RESTful API architecture

Figure 4 presents the connection between the client and back-end sides which occurs in one type of requests and get JSONArray or JSONObject as a response.

In this research, web services can be accessed for the connection between the back-end and client side through the following IP and Port:

IP: http://195.248.241.152
Port: 8080

Service Usability1: Send Alarm from client to server.
Route Name 1: /basicInf/alarmAccident
Input1: latitude, longitude
Ouput1: empty (/200 ok)

Service Usability 2: Get Nearest Hospital to one location
Route Name 2: /basicInf/getNearestHospital
Input 2: latitude, longitude, deviceId
Ouput 2: JSONFile

Service Usability 3 (Figures 5 and 6): Get all coordinates of hospitals.
Route Name 3: /basicInf/getAllCoordinatesOfHospitals
Input 3: empty
Ouput 3: JSONFile

Figure 5: The result of web service 3: Get all coordinates of hospitals (chart parse).

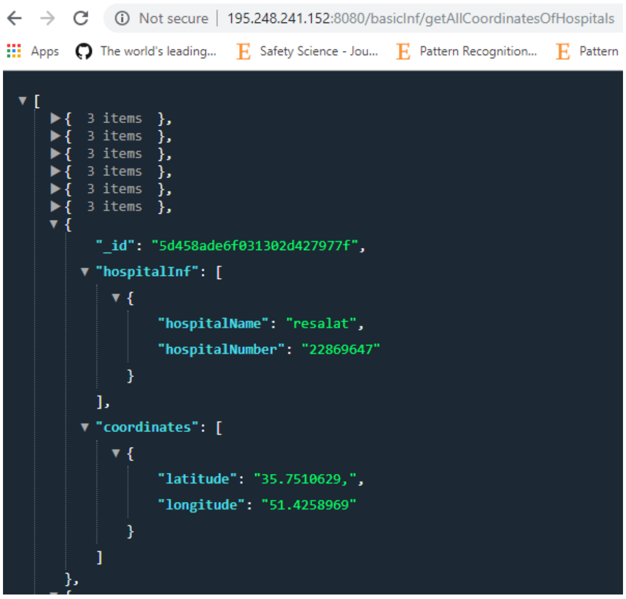

Figure 6: The result of web service 3: Get all coordinates of hospitals (JSON parse).

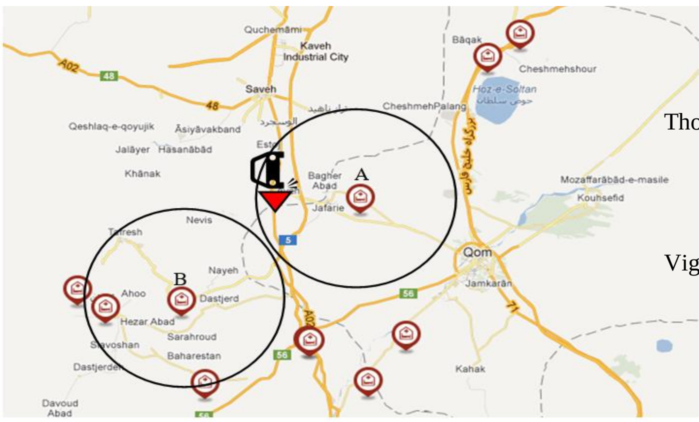

Figure 7: Emergency centers are shown using the data from road traffic authority website.

5. CONCLUSION

This research is concerned with the design and implementation of an intelligent accident alert system which not only notifies accident alerts but also provides the exact car accident or crash location. Thanks to OBU, the accidents will be detected and after that a notification will sent to the server. Then the server sends a request for assistance to the nearest rescue center. The results show that using this system reduces the Ambulance Arrival Time (AAT) through the integrated alarm system. Then the ROD was shown when using the proposed system and otherwise. Comparing of these RODs, the reliability of this system is improved with respect to that of the similar systems.
It is suggested that in future, further development of the constructed board and its integration with more sensors such as alcohol or fire detection sensors can be considered. In addition, a camera can be installed on this board to control healthy status of the passengers.

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