Black-box Accident Detection and Location System Based on the Raspberry Pi

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Abstract. Nowadays, traffic accidents are one of the main reasons of fatalities in the world, many lives can be saved by reducing the time between the occurrence of an accident and the arrival of first help at its location. In research literature, numerous accident detection and notification systems were proposed to solve this problem. Including built-in unit, black-box, and mobile phone-based solutions. Our research has been devoted to design a black-box system that integrates Global System for Mobile Communication (GSM) and Global Positioning System (GPS) technologies to locate and send a Minimum Set of Data (MSD) containing important information about the accident collected using different sensors such as the accident type, longitude and latitude, time and speed of the vehicle to the emergency services (Hospitals, civil protection, and police). This system is developed based on the Raspberry Pi 3 in order to provide both low cost and high system performances.

Keywords: Accident detection · GSM · GPS · MSD · Raspberry Pi 3

1 Introduction

In today's world, Transportation has submitted great development over years. Unfortunately, this was a major reason of increasing the rate of fatal traffic accident [1]. Every year, nearly 1.2 million people die in road crashes. Besides, 20–50 million people are either severely injured or disabled [2].

As it was proven by previous researches, the traffic accident fatality is strongly depending on the response time of the emergency services: the time lapse taken by the intervention units to get to the accident site [3].

Automated car accident detection, or eCall systems, can reduce the response time of the emergency responders. In result, many lives could be saved, and the seriousness of the injuries can be decreased [3].

In order to provide rapid intervention services, we propose an Accident Detection and Location System (ADLS) that can send a Minimum Set of Data (MSD) from the vehicle to the emergency services [4]. This MSD contains the following information: -

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Accident type - Accident location (Longitude and latitude) - Time of the accident – Speed. The proposed system utilizes the GPS technology to calculate the exact longitude and latitude coordinates of the vehicle and send them through the Global System for Mobile communication (GSM) network to the emergency services. It also uses the Raspberry Pi to manage the acceleration and many other information collected using different types of sensors.

2 Related Works

eCall is an emergency call which allows to send an MSD to the Public Safety Answering Point (PSAP), it can be operated either manually by the occupant of the vehicle via the call button or automatically following a serious collision [5].

2.1 Built-in Units

Automobile manufacturers are currently working to equip their newer cars with an integrated (Built-in unit) eCall systems. The main advantage of such type is the possibility of accessing to the status of any in-vehicle sensor to determine the occurrence of an accident, such as accelerometers and airbag deployment monitors [3].

2.2 Black-Box Solutions

Unfortunately, most cars in countries where the average age of vehicles is much higher do not have automatic accident detection and notification systems (White et al. 2011). The perfect solution in this case is the use of 'Black-box' eCall solutions, standalone or deployable devices, which have personal, dedicated hardware for sensing, location and communication functions [3].

2.3 Mobile Phone Based Solution

With the widespread use of mobile communications devices, almost every passenger in a car owns a smartphone. This includes the main technical components, which are required by an eCall system (Accelerometer, GPS and GSM communication) [3]. Smartphone-based accident detection applications have both advantages and disadvantages relative to Built-in unit systems, e.g. they are not directly connected to the vehicle, and provide valuable data for accident analysis, including pictures and videos. However, they are not precise compared to other solutions because they can generate false positives [6].

3 Proposed System

The presented black-box system in this paper can reduce the response time by generating an automatic alerting message, indicating the location of the vehicle using a GPS device. This message will be sent to the emergency services, which will decide on

the follow-up to be given to the alert. Since the time factor is essential in this type of emergencies, this process will save valuable time.

The proposed system architecture is depicted in Fig. 1. In the event of a traffic accident, an accident detection algorithm (ADA) will manage different data sources to detect the accident and give the order to the Raspberry Pi, which in turn will generate and send an alerting message to the emergency services using the GSM module containing the car's accident information.

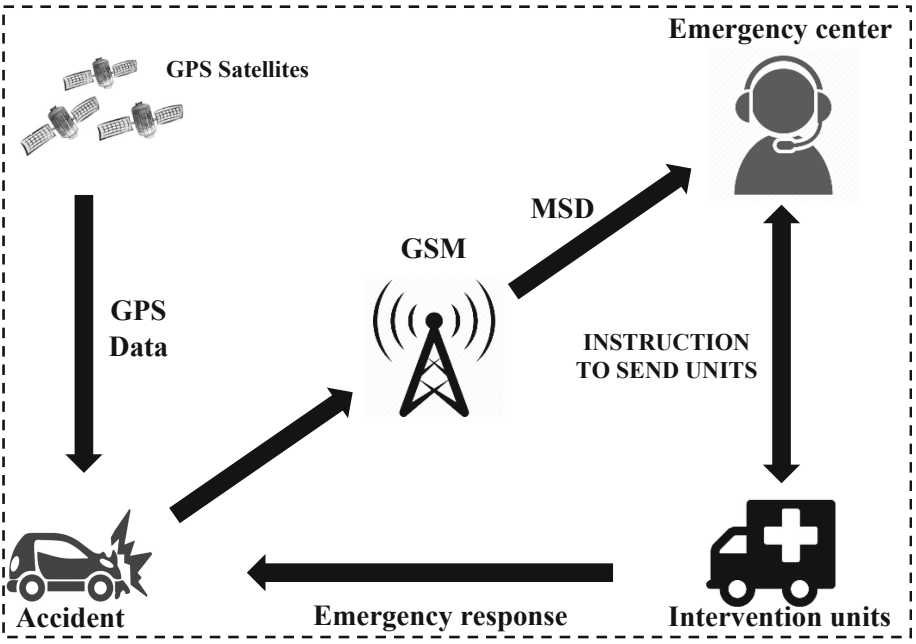

Fig. 1. Diagram of the proposed system.

4 Hardware Architecture

In order to provide and implement the eCall mechanism, an ADLS hardware architecture has been proposed and developed as shown in Fig. 2. The system is connected to the vehicle via the OBD-II communication. A Raspberry Pi 3 is utilized as a main system controller equipped with 1.2 Ghz of processing frequency to manage the different system's devices, the NEO6M V2 GPS module is used for locating the accident, where the responsible device of the mobile communication is a SIM900A GSM module.

The system is built as a mobile unit, this allows for possibility of displacement and maintenance.

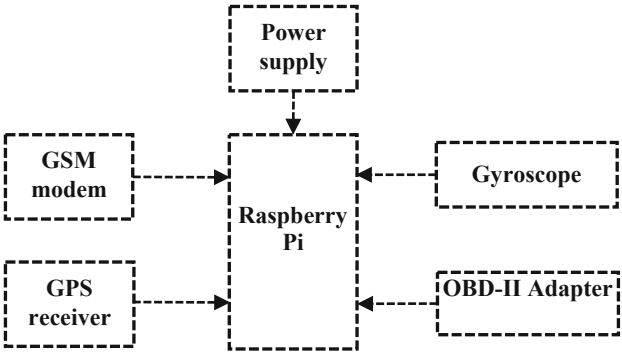

Fig. 2. System hardware architecture.

5 GPS for Accident Detection Systems

The Global Positioning System (GPS) is a satellite-based navigational system designed and operated by the US department of Defense for military and civilian use [7]. The GPS module determines the location of the car accident by comparing the time signals it receives from a number of satellites and triangulating on the known positions of each satellite. GPS can provide the accurate location of the accident place [8].

The GPS receiver provides data through Universal Asynchronous Receiver Transmitter (UART) depending on the NMEA(National Marine Electronics Association) standards, NMEA specify the communication by several sentences which are independent from each other [8].

The $GPRMC sentence from the NMEA 0183 communication protocol is widely used to transmit data in GPS devices. The time, latitude, longitude and speed can be extracted from the $GPRMC sentence. The format of the $GPRMC sentence is presented in Fig. 3 [9, 10].

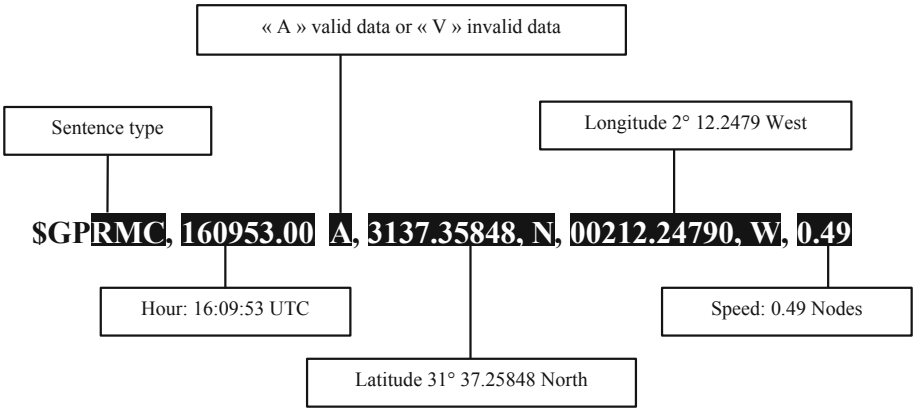

Fig. 3. The $GPRMC sentence.

The GPS data requires conversion before being useful, the latitude and longitude must be converted from the initial format provided by the $GPRMC sentence (Degrees, minutes, and seconds: ddmm.ssss) to decimal coordinates (dd.mmssss).

6 Data Transmission Procedure

The accident detection system must send the accident information in real-time to the emergency services in order to provide fast intervention, a Short Message Service (SMS) is sent through GSM modem which contains the longitude and latitude, occurrence time, speed, accident type and the accident severity based on the deceleration value.

The raspberry Pi can control the GSM modem via AT commands. At first, the echo is disabled using the 'ATE0'command. The 'AT+CMGF=1' is used to set up the text mode (SMS) and the 'AT+CMGS' command is utilized to send the SMS to the preselected recipient number.

7 Accident Detection Algorithm

In this paper, the vehicle accident detection phase is based on the use of different sensors depending on the type of the accident. The shock sensor is used to detect the vehicle collisions, the system has also gyroscope and flame sensor in case of vehicle overturn or burn respectively. The accident location phase will then be activated in order to obtain the exact position and time of the accident using the GPS technology, this information will be sent to the emergency services as well as the accident type through the GSM communication. The flowchart of the proposed algorithm for accident detection system is represented in Fig. 4.

8 Result and Discussion

A robust accident detection and location system has been developed and presented in this paper, an accident detection algorithm has been implemented and tested in order to detect the vehicle accident in its different types and send its location obtained through the GPS system using the GSM communication. Fig. 5 shows the test of the shock sensor using the system prototype by applying strong vibration, when Fig. 6 Shows the test of the flame sensor. Figs. 7 and 8 show the test of the vehicle overturn right and left respectively.

The system send a short message service to preselected number containing important information such as the accident type, time and the exact location of the accident, the message format is depicted in Fig. 9.

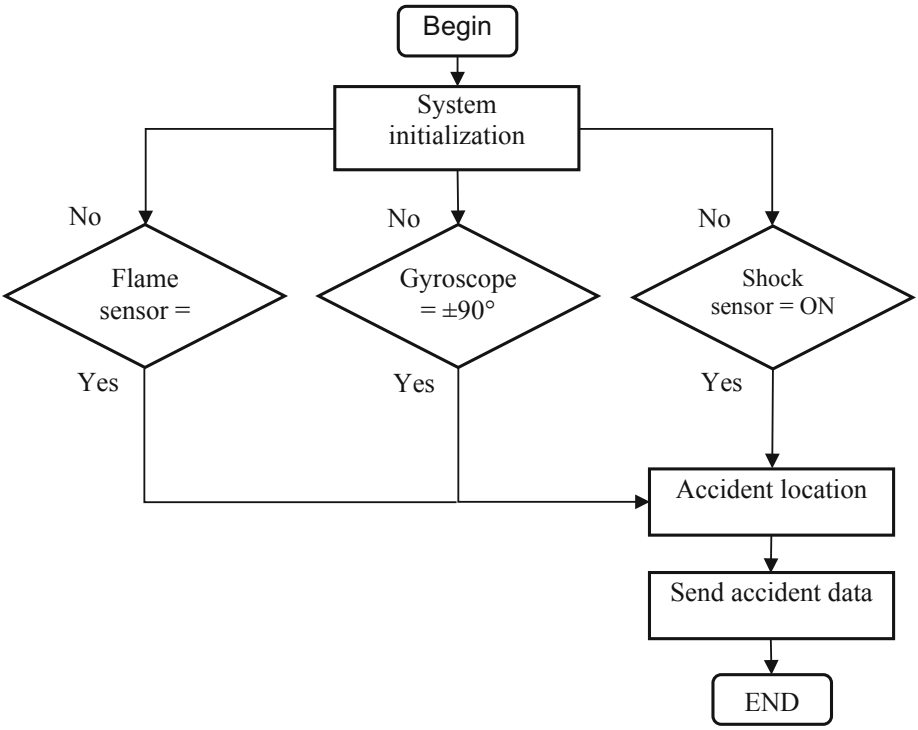

Fig. 4. Organigram of the accident detection algorithm.

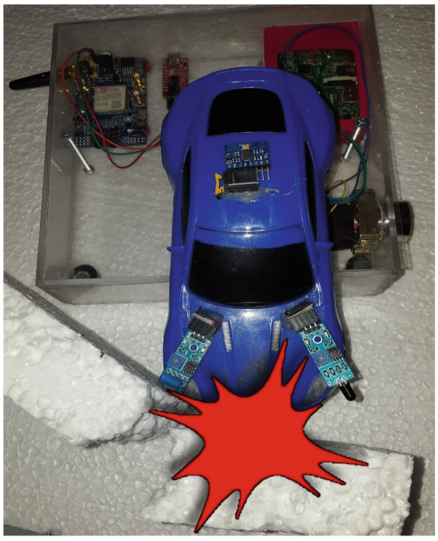

Fig. 5. Test of the vehicle collision detection system.

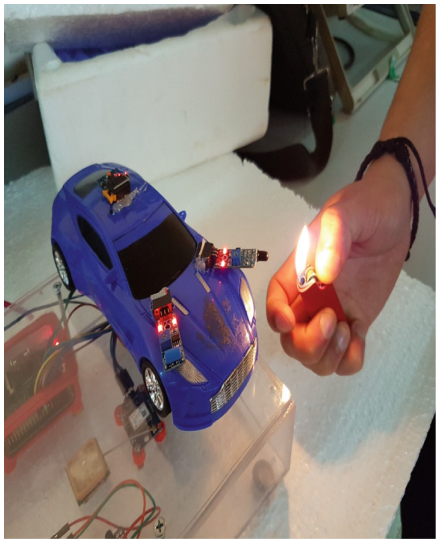

Fig. 6. Test of the vehicle fire detection system.

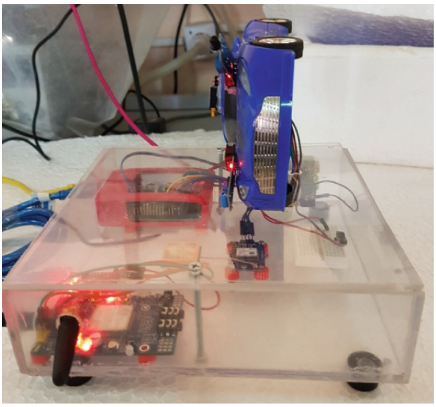

Fig. 7. Test of the vehicle overturn detection system (right).

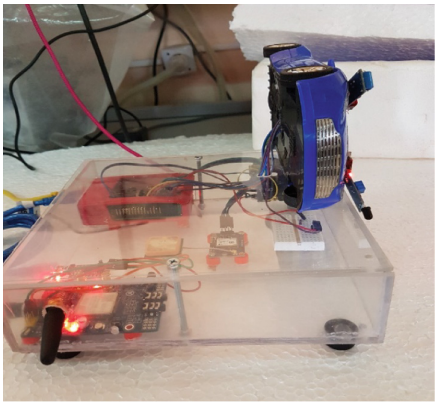

Fig. 8. Test of the vehicle overturn detection system (left).

Fig. 9. The SMS format.

9 Conclusion

In this article, the authors presented an Accident Detection and Location System, which provides robust detection mechanism of road accidents using fast reporting method using both GPS and GSM technologies. The main contribution in our system centered on the idea of using the Raspberry Pi as a main system controler. The response time of the system doesn't exceed 20 s which is a good result. In future work, we are planning to ameliorate the system in order to add more accurate accident detection procedure and test the system by simulating real vehicle accidents.

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