Vehicle monitoring based on GSM technology for safety and security

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Abstract: Information and communication technologies (ICT) have contributed greatly to society by solving many emergent problems to allow people to lead easier lives. One such problem is vehicle monitoring during parking or driving to ensure that the vehicle and the persons inside are in safe conditions. This research proposes a vehicle monitoring system using wireless technology and employing mobile phones and Arduino microcontrollers. The functions of the proposed system include sending alarm messages to the vehicle driver in case the vehicle is broken into or stolen. Further, in case of accident or exposure to the crime of theft or abduction during driving, the driver can send appeal messages, including the vehicle position, to family, friends, police, and ambulance services using only a single click. The system achieves these functions automatically in cases where the vehicle is erratic or in significant collisions. The communication distance between the vehicle and the receivers of the messages allows coverage in all regions served by mobile networks, thus covering a wide range. The system has been tested for several different cases and has succeeded in tests.

1. Introduction
According to the World Health Organization (WHO), road traffic accidents are the eighth leading cause of death globally [1]. This rate is predicted to increase such that, by 2030, traffic fatalities will be the fifth most common cause of death in the world [2]. The number of the road traffic deaths around the world was over 1.25 million in 2013 [2]. It is clear that huge numbers of deaths, as well as many more injuries, are being caused daily by traffic accidents. This has led to significant efforts being made in many countries to reduce traffic accidents using advanced transportation systems that integrate electronics, communication devices, and mechanical and automotive engineering [3–5]. However, in many countries, especially those of low and middle income which have more than double the incidence traffic death seen in high income countries [2], advanced transportation systems have still not been developed. Hence, standalone technologies, which can be installed in individual vehicles and do not require servers provided by governments or companies, are optimal responses to such issues in these countries. The system proposed in this paper is an example of standalone installed technology that calls an ambulance directly when an accident happens in order to reduce the death rate from such accidents.

Work in recent years has discussed vehicle safety problems from several directions. One of these is vehicle warning systems, which use communication networks to improve driving safety, as in [6–9]. Other research work has focused on vision radar systems (VRS), integrated Lane Departure Warning Systems (LDWS), and Forward Collision Warning Systems (FCWS) to increase car safety during driving, as in [10]. Car-to-car safety applications in real time systems that utilise vehicular ad-hoc networks were implemented in [11], and another research direction in vehicle safety is the employment of microcontrollers, Wi-Fi, and Bluetooth communications to provide safety instructions to drivers as seen in [12][13][14]. Several other researchers have been concerned with the provision of vision and audio instructions offering support to the driver, as in [15][16][17].

An additional problem related to vehicles is the increase in vehicle thefts; thus, anti-theft systems have grown to play a major role in vehicle security, and many researchers have done work in this area. In [18–20], an antitheft system for vehicle security was implemented by utilising sensor-network system which employed Global Positioning System (GPS) technology to track the vehicles.

This paper proposes a somewhat similar monitoring system, which is connected to the vehicle and provides a number of security and safety facilities. The proposed system is designed and implemented...
based on a microcontroller, global system mobile (GSM), GPS, and gyroscopes. It performs the following tasks:

1- Alarms the registered driver of the parked vehicle if it is opened or taken by producing a ringing tone and delivering an SMS message with the vehicle position. The registered driver can locate the vehicle at any time through such SMS messages.

2- Sends an appeal message automatically to the ambulance service, police, family, and/or friends in the case of a serious accident.

3- Allows the driver to send appeal messages with a single click in the case of less urgent incidents.

2. The proposed system

The proposed system is designed and implemented by employing an Arduino microcontroller with several add-on technology modules that include GSM, GPS, a gyroscope, and sensors. The GSM is used to provide a simple communication system between the vehicle and relevant persons such as the registered driver, ambulance services, the police, family, and friends. The GPS is used to identify the vehicle position, while the gyroscope is used to measure the vehicle's equilibrium and thus detect any dangerous accident such as the vehicle rolling over. The sensors used include lights on the doors, bonnet, and boot that are ON if the doors, bonnet, and boot are opened.

Figure 1 shows a block diagram of the overall system. The system is supplied by a nine-volt source or can use the vehicle battery directly (12 volts). A GSM of type SIM900A is connected to pins 0 and 1 of the Arduino. These two pins are serial communication pins. Pin number 2 is used to read the revolutions per minute (RPM) meter, which represents the engine speed. Pins 3 to 5 are used to check the lights of the door bonnet and boot respectively. Pin number 6 is used to check the status of an appeal key (AK) that can be pressed by the driver in an emergency to send appeal messages to family, ambulance services, and the police. A GPS of type 6Y-GPS6MU2 is connected to pins 10 and 11, and this is provided with 3.3 volts from the Arduino board. Finally, a gyroscope of type L3G4200D is connected to the clock (SCL) and data (SDA) pins that support two wired interfaces (TWI) [21]. The gyroscope is provided with five volts from the Arduino board.
2.1. **Algorithm of the proposed system**

The system is designed to operate manually or automatically according to the risk encountered by the vehicle and the people inside it. The system automatically calls the registered driver with a set tone and an SMS messages if the vehicle is opened. Moreover, if the vehicle is stolen, the driver can easily locate it by sending and receiving SMS messages. Additionally, the driver can send appeal messages while driving to family, police, and/or ambulance services with only one click if any risk is encountered. An additional task undertaken by the system is the sending of automatic appeal messages in case of the vehicle flipping. Figure 2 shows the algorithm flowchart in detail:

![Algorithm flowchart of the proposed system.](image_url)
The steps of the system algorithm shown in Figure 2 are as follows:

**Step 1:** The system must first be activated. Subsequently, it checks the status of the vehicle to see if it is in operation or turned-off mode. This check depends on the RPM meter, which has value greater than zero where the vehicle is in operation mode. Subsequently, if the vehicle is in turned-off mode, the system executes step two; otherwise it executes step three.

**Step 2:** If vehicle is in off mode, the system reads the DL, BL, and BtL pins. Subsequently, it checks if any of these is triggered, and if so, calls the registered driver with a ring tone, sending an SMS message; otherwise, it returns to step 1.

**Step 3:** If the vehicle is in an operation mode, the system first checks if any SMS message from the registered driver have been received. If a message is received, it will read GPS position from pin 10 and send SMS message with the vehicle position via pin 1, before returning to step 1; otherwise, it checks the appeal key (AK) and reads the changes in the elevation and azimuth angular velocities, $\Delta\omega_\theta$ and $\Delta\omega_\phi$ respectively, from the SDA pin. Subsequently, if the AK is high or the changes of $\Delta\omega_\theta$ and $\Delta\omega_\phi$ are greater than the threshold set, which refers to the risk to the vehicle's equilibrium, then the system sends appeal messages; otherwise it returns to step 1.

3. **Experimental Results**

In order to test the proposed device, the RPM meter was replaced by pushbutton switch (see Figure 3), and the door, boot, and bonnet lights were simulated with LEDs with high voltage when ON and low voltage when OFF. The LEDs were connected to 10 kΩ resistances and supplied with five volts. The GSM was provided with an activated SIM card and nine volts.

Two main tests were made. In the first one, the proposed device sent a message to the registered driver when any LED was ON or if the driver requested the vehicle position from the device via an SMS message. Figure 4 shows the message received by the driver, which includes the vehicle position. In the second test, the device sent SMS messages to the specified family and friends, as well as to the ambulance service and police in cases of sudden changes to the gyroscope or if the appeal key was pressed. Figure 5 shows the messages received by such family and friends, which includes the vehicle position. The appeal messages were received by the desired people in only seconds for all the above tests.

4. **Conclusion**

This paper has investigated a proposed monitoring device that offers security and safety services for vehicles. The proposed device was implemented using an Arduino board with GSM, GPS, and gyroscope add-ons. The device calls the registered driver if the vehicle is opened or stolen, delivering a ringing tone and an SMS message that includes the position of the vehicle. Furthermore, the device can send appeal messages to family, friends, ambulance services, and the police during vehicle operation where the vehicle is at risk. In future work, the proposed device will be connected to a vehicle by means of the on-board diagnostic system, OBD-II, to make it more compatible with the vehicle.
Figure 3 Snapshot of the proposed system using a push-button switch instead of PRM.

(a) Alarm message from the proposed device
(b) Map of the current position of the device

Figure 4 Message by the registered driver that includes the position of the stolen vehicle.
Figure 5 Appeal messages and position of the vehicle in case of accident or risks.

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