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Crash Alerting and Data Logging System for Remote Monitoring of Automobiles

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ABSTRACT: Data logging is the process where a physical quantity such as the temperature, pressure, force, voltage, etc. are acquired continuously at pre-defined intervals and then stored, for analysis. A vehicle data logger, which is also called vehicle monitoring system, is able to record the vehicle location autonomously over a distinct period of time. Global positioning system (GPS) data loggers are commonly used in tracking the movements of automobiles and trace stolen automobiles. There are several commercially available GPS based data logging devices in the market. These devices basically include a built-in GPS receiver and electronics to capture the user geographical coordinates and store them either in the internal memory of the devices, or on an external memory card. Mobile technologies such as GSM and GPS can be used for displaying the current position of the vehicle indicating as the latitude, longitude, time, data and driving speed. GSM is the most commonly used service for this purpose. The secure digital (SD) card is widely used as storage media for a portable device. During vehicle motion, the position data, time, date and driving speed are reported by a blue tooth module to the driver. The data of the vehicle at a remote location can be seen at the mentioned cell phone. The GPS is used to determine the precise location of a vehicle to which it is attached and its location is transmitted to a known mobile number using GSM. This work involves logging the data of a vehicle using latest technologies of GPS, GSM and SD card. The developed module alerts vehicle crash at remote location and transmits the data to the monitoring location.

KEYWORDS: Data logging, remote monitoring, GSM, Bluetooth

I. INTRODUCTION

Out of the estimated 1.4 million collisions occurring annually in India, hardly 0.4 million are recorded. Further, only a minimal percentage of these collisions are scientifically investigated, in the absence of which, the real causes and consequences are never known. Therefore remedial measures as well as punishment for the violators are also arbitrary. On account of various conditions, generally, the larger vehicles are often labeled the culprit in cases of vehicle-to-vehicle crashes. Road safety can only be improved when causes and consequences of road collisions are analysed, which can be used to work out remedial measures. Six of the most common new technologies are forward collision warning, topple, auto-brake, lane departure warning, lane departure prevention and blind spot detection. Research has shown vehicles equipped with these technologies are less likely to collide. A vehicle is possible of rotating in three different directions after the collision. There is a possibility of the vehicle getting rotated in three degrees of freedom in three orthogonal axes as shown in Fig.1.1. Namely roll, pitch, yaw are rotations of the vehicle along x, y, z axes respectively.

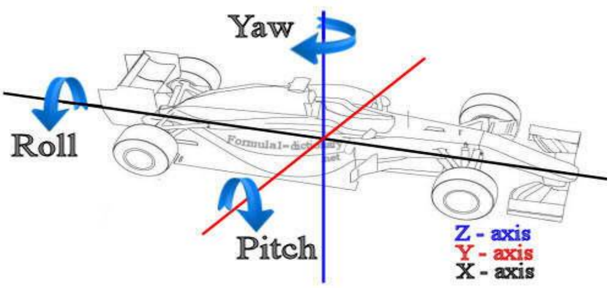

Fig 1.1 Vehicle rotation in three directions during collision

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II. LITERATURE REVIEW

Work done by Le-Tien [1] et al describes a system based on the GPS and global system for mobile communication (GSM). It describes the practical model for routing and tracking with mobile vehicle in a large area outdoor environment. The system includes the compass sensor-YAS529 of Yamaha company and accelerator sensor-KXSC72050 of Koinix company to acquire moving direction of a vehicle. The system acquires positions of the vehicle via GPS receiver and then sends the data to supervised center by the short message services (SMS). Subsequent work carried out by El-Medany [2] et al describes a real time tracking system that provides accurate localizations of the tracked vehicle with low cost. GM862 cellular quad band module is used for implementation. A monitoring server and a graphical user interface on a website was developed using Microsoft SQL Server 2003 and ASP.net to view the proper location of a vehicle on a specific map. The work provides information regarding the vehicle status such as speed, mileage. Durisek [3] et al had proposed the measurement method which is performed by oscillating the vehicle in yaw and monitoring the resulting yaw acceleration and roll torque. The product of inertia is calculated from equations representing the motion of a rigid body relative to a nonmoving reference frame modified to accommodate for the misalignment of the vehicle. Chen Peijiang [4] et al has described the wireless remote monitoring system has more and more application, a remote monitoring system based on SMS of GSM. Based on the total design of the system, the hardware and software of the system is designed. In this system, GSM network is a medium for transmitting the remote signal. The system includes two parts which are the monitoring centre and the remote monitoring station. The monitoring centre consists of a computer and a TC35 communication module of GSM. The computer and TC35 are connected by RS232. The remote monitoring station includes a TC35 communication module of GSM, a MSP430F149 MCU, a display unit, various sensors, data gathering and processing unit. The result of their demonstration showed that the system can monitor and control the remote communication between the monitoring centre and the remote monitoring station, and the remote monitoring function is realized. Paul Benjamin Fleischer [5] et al has proposed the design, development and deployment of GPS/GSM based vehicle tracking and alert system which allows inter-city transport companies to track their vehicles in real-time and provides an alert system for reporting armed robbery and accident occurrences. Sakhi [6] et al describes a design of a data logger based system dedicated to vehicle trajectory monitoring. The system evaluation was based on prototyping an embedded application. The adopted architecture allows tests and applications and results are obtained with a set of constraints. In this multisensory architecture, a GPS receiver was used for the absolute localization. In order to integrate the GPS module in the data logger, an architecture study was carried out. The corresponding measurement results were presented and analyzed. In a second step, a calibration procedure was applied to the implemented A/D data converter. Their results gives an over view of the future development. Kucera [7] et al presented a vehicle data acquisition system. This system was a part of the car transport safety project that is aimed at modern methods in the vehicle transportation systems. The goal of the work was to reduce hazardous situations on the roads by analyzing behavior of the driver and identifying the degradation of driver's abilities. The goal of the vehicle data acquisition system was to create a publicly available data archive taken from the operation of a real car under various real conditions of the driver and the road. The data was collected from a vehicle's communication bus and from an image acquisition system. Data was processed with the aim to analyze it and reveal changes in a driver's abilities and to eventually alarm the driver or passenger. Brammer [8] et al described the Furon data logging system, giving details of its capabilities and applications. The system uses are split into two main areas, vehicle performance monitoring and driver performance monitoring. The system was intended to be used by companies that operate a fleet of cars, vans or trucks such as delivery companies, utilities, or county councils. The applications were often across a fleet of varying types of vehicles. The system was designed to be easy to use and requires no input from the driver of the vehicle. Qayyum [9] et al described the real-time vehicle tracking system (VTS) as a system that uses GPS to track and plot the location of its vehicle on the map. VTS combine GPS technology, cellular communications, street-level mapping, and an intuitive user interface, with the ostensible goal of improving vehicle tracking and customer service. For example, a customer using VTS system is able to pinpoint the longitude, latitude, ground speed of a given vehicle. The vehicle's location can be quickly found and it could be rerouted to provide timely delivery to a nearby customer. VTS systems also enable customers to track their vehicle on mobile phone. VTS systems include a network of vehicles that are equipped with a GPS receiver, a GSM modem, and a laptop. This network connects with a base station consisting of a PC computer station as well as a GSM modem and interface. Where any vehicle can be viewed on the map by moving dot real time VTS systems can be used to increase customer's dispatching procedure and measure field personnel's live performance. Blum [10] presented steps of programming on Arduino, and related hardware for the development of such applications.

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After the study of existing literature, it is motivated to develop a system for crash alerting and monitoring with the objectives of

- Acquiring the roll, yaw and pitch data from accelerometer and identify the status of the vehicle during crash.
- Developing an interface for continuous data-logging of the measured parameters.
- Determination of vehicle location upon detection of a crash.
- Sending the vehicle status along with the crash location to a phone number after a crash.

III. METHODOLOGY

The module was designed to find out the exact location of any vehicle and intimate the position to the concerned authority about the crash through an SMS. Accelerometer was used to detect the changes in the angles along all three directions which are obtained in terms of variation of electric signals. In order to have compatibility between the sensing section and the controlling section, signal conditioning using auxiliary circuits like analog to digital converter were used to acquire signal from the sensors as shown in Fig.3.1. After acquisition of data, microcontroller program was implemented to compute parameters and convert into standard values, in angles. All these data were communicated to a display device via wireless interface (Bluetooth protocol) so that the angles can be observed in real-time and take corrective measures for optimum and safe performance.

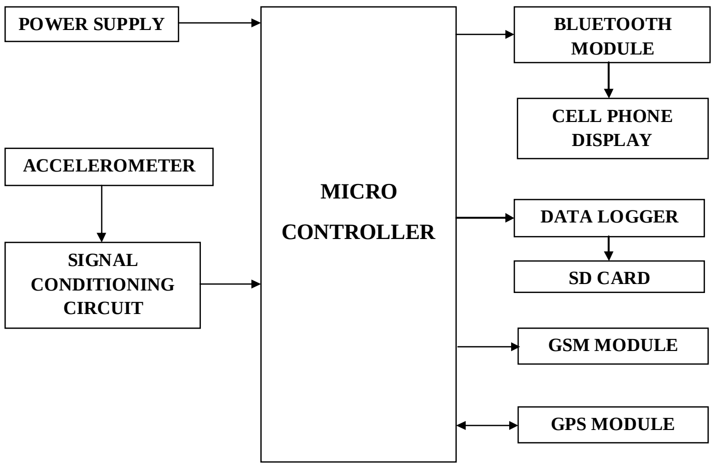

Fig. 3.1 Block diagram of crash alert and data logging system.

Furthermore, all this acquired data was logged onto a SD card for future reference for the sake of maintenance and performance history evaluation. This system includes a GPS modem which retrieves the location of a vehicle in terms of its longitude and latitude. This data was fed to the microcontroller which was interfaced with a GSM modem. Microcontroller retrieves the location details from the GPS after a crash and sends it to the concerned authority in the form of an SMS over GSM modem after a crash. A mobile display was interfaced using Bluetooth to the microcontroller for cross checking the data received before being sent over GSM.

The ADXL335 is a complete 3-axis acceleration measurement system with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the X_{OUT}, Y_{OUT}, and Z_{OUT} pins as shown in Fig. 3.2. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The ADXL335 uses a single structure for sensing the X, Y, and Z axes. The 3-axis accelerometer is based on the principle of capacitive sensing. The sensor is made of spring loaded, micro machined structure, mounted on silicon base. Force on the structure changes the position of seismic mass attached on

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the spring. This deflection is measured using fixed plate capacitor sensors. The change in acceleration unbalances capacitor plate distance, observed by modulation/demodulation circuits and thus, resulted in output proportional to acceleration. The sensing can be static or dynamic.

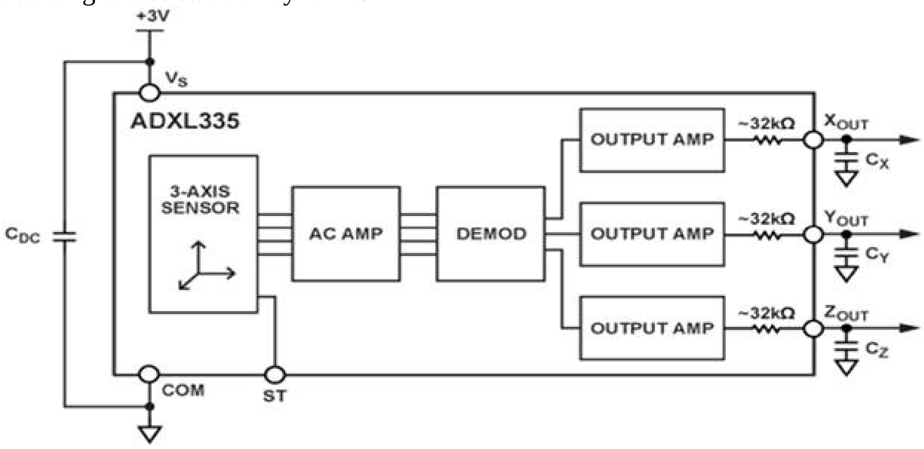

Fig. 3.2 Signal conditioning for ADXL335

Data Logging was done using an SD card module. The SD card module was a micro SD card reader module, and the SPI interface via the file system driver. Microcontroller was used to read and write files. Micro SD card interfaces to control the direction of the MISO signal which is also converted into 3.3V. General Arduino microcontroller system can read the signal.

SIM908 module is a high performance industrial GSM/GPRS/GPS module. The interfaces of this development board are rich, perfect functions, especially is suitable for the need to voice/SMS/GPRS/GPS navigation data service of all kinds of fields. An important technical feature is the serial adapter for the communication between the GSM module and Arduino. To reduce the tension has been used a simple voltage divider, while for raising the voltage from the GSM module to Arduino, a MOSFET BS170 was used.To preserve compatibility with the Arduino Mega, the selection method for the serial communication was changed. The two different serial communication modes (hardware or software) are selectable by jumper, leaving the user the choice between the two configurations (for serial software in this new version we adopted pins 2 and 3) or possibly use the pin to one's choice with a simple wire connection. With this solution one can use the Arduino Mega using two of the four serial that it has, or possibly carry out the communication through serial software via two pins of one's choice.

Bluetooth is a global wireless communication standard that connects devices together over a certain distance. It is built into billions of products on the market today and connects the Internet of Things (IOT). A Bluetooth device uses radio waves instead of wires or cables to connect to a phone or computer. Communication between Bluetooth devices happens over short-range, ad hoc networks known as piconets. A piconet is a network of devices connected using Bluetooth technology. The network ranges from two to eight connected devices. When a network is established, one device takes the role of the master while all the other devices act as slaves. Piconets are established dynamically and automatically as Bluetooth devices enter and leave radio proximity. Cell phone is used as the Bluetooth output device. The system includes an RF transceiver, baseband and protocol stacks that enable devices to connect and exchange a variety of classes of data. Bluetooth devices exchange protocol signaling according to the Bluetooth specification. Core system protocols are the radio (RF) protocol, link control (LC) protocol, link manager (LM) protocol and logical link control and adaptation protocol (L2CAP), all of which are fully defined in the Bluetooth specification. The lowest three system layers are the radio, link control and link manager protocols which are often grouped into a subsystem known as the Bluetooth controller. This is a common implementation that uses an optional standard interface which includes the host to controller Interface (HCI) that enables two-way communication with the remainder of the Bluetooth system, called the Bluetooth host.

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IV. RESULTS AND DISCUSSION

In this work, the circuits using Arduino are implemented. Arduino is an open-source platform used for building electronic controllers. Arduino consists of both a physical programmable circuit board (referred to as a microcontroller) and a required software, or IDE (integrated development environment) that runs on computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate hardware (called a programmer) in order to load new code onto the board, one can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of the programming language making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the microcontroller into a more accessible package.All the acquired data is logged onto an SD card. Table 1 shows one set of basic data. Future reference of data is required for maintenance and performance history evaluation.

Table 4.1 Set of transmitted and logged data

PARAMETERS	VALUES
Roll	86.40^0
Pitch	60.12^0
Yaw	74.18^0
Latitude	7636.81E
Longitude	1216.96N
No. of satellites	9.00
Altitude	595.00 m
Speed of the vehicle	0.00 knots

All the data is communicated to a display device by wireless interfacing (Bluetooth protocol) so that angles can be observed in real-time operation of the vehicle and take corrective measures for optimum and safe performance.GSM technology is used to send the below details in the form of text message after the vehicle has crashed to a specified number. Final hardware set up of the prototype which includes Accelerometer ADXL335, Bluetooth module HC05, Arduino MEGA board. SD card module, 12V power supply for controller, GSM antenna, and GPS antenna is shown in Fig. 4.1.

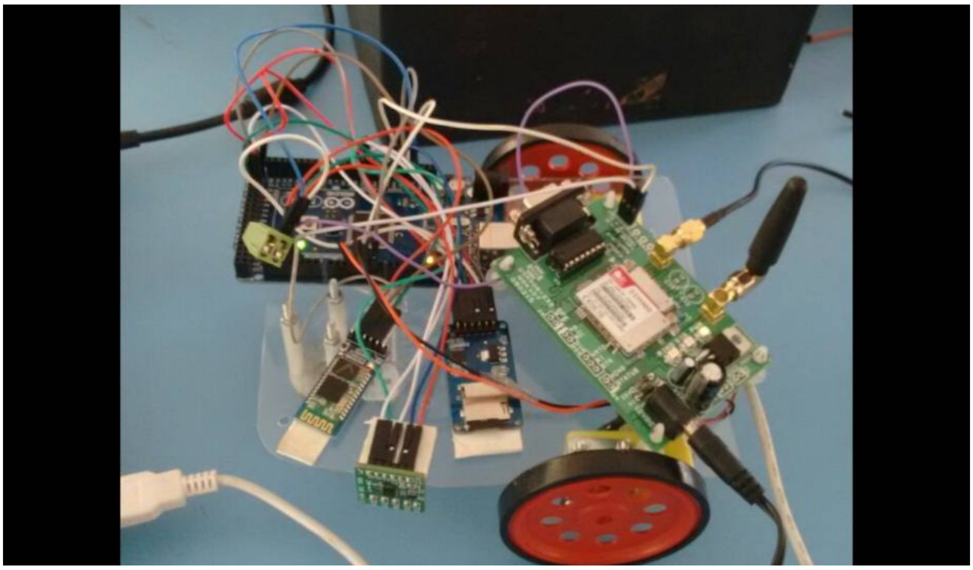

Fig. 4.1 Final set up of the prototype

V. CONCLUSION

In the proposed concept, the vehicle is not tracked continuously. Whenever the vehicle is crashed, location information is transmitted to the concerned mobile automatically. This saves GSM bandwidth. Our system is versatile as it can be used on cars, trains and two-wheelers. If the vehicle crashes, moves for some distance and then stops, it will be difficult to acquire the actual location of the vehicle. To avoid this, a message is triggered only after the vehicle has completely stopped. The capacity of the data logger used in our prototype can be expanded up to 64GB based on user requirements. Our prototype has multiple advantages:

- It can used to map crash spots in cities and highways.
- If the vehicle is stolen and abandoned, its path can be retraced by retrieving the data that is logged in the SD card.
- Reference data provided is helpful for the driver to take corrective measures.

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