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Emergency Alert and Service for Automotives for India

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Abstract: Road accident due to drunken driving is one of the major concerns in India. This paper aims at giving a solution for the same problem by utilizing effective communication technology. The system consists of a microcontroller unit, a GPS receiver, a GSM Module and CAN transceiver, Alcohol Sensor. The system is intended to capture the location of the vehicle through GPS receiver, send the location information to vehicle owners mobile number through SMS and also to the telematics operator server through GPRS .In case of emergency, the module is also capable of making call. The system can be used for tracking purpose. The customer can track his vehicle online: vehicle position is shown on Google Map. The module also sends alerts to the telematics Operator Server and to vehicle owner's number in case the vehicle crosses the virtual fence and/or detects an dangerous alcohol level in the driver. This module can also interact with other ECUs present in the vehicle through CAN.

Key words: Drunken Driving Alert, Geo-Fencing, GPRS, GPS, Vehicle tracking

INTRODUCTION

India has 3.3 million kilometers of road network which is the second largest in the world. Over 65% of freight and 87% of passenger traffic in India is supported by the road network and is expected to grow by over 14% per annum; supporting that automotive telematics does have a role in India. During last few decades growth of automobile sector is tremendous in India. Increasing number of automobile accidents has become major cause of concern. Although many efforts taken by governmental bodies and NGOs, Road Accident related deaths are on rise. According to World Health Organization report, India, along with China, is listed among countries with the highest number of deaths due to road accidents. A study conducted by Alcohol & drug Information Centre (AIDC), India revealed that around 40% of the road accidents have occurred under the influence of alcohol. The number of death and disabilities due to road accidents and drunken driving can be reduced, if timely alerts can be sent and if the victims can be given timely aid. Therefore, many researchers and automobile manufacturing companies are coming up with services to help the needy people. Recent development in vehicular communication technology has led the path to improve the rescue time and detect drunken driving.

Most Intelligent transportation system (ITS) applications depend on Information & communication technology between vehicle to Infrastructure (V2I), Infrastructure to vehicle (I2V) and/or vehicle to vehicle (V2V). In fact, the 802.11p working group recently approved the IEEE 802.11p standard [1] which provides a viable solution for inter-vehicular security applications. This technology already has been studied to increase traffic safety in dangerous areas such as intersections [2].

In India Global system for Mobile communication (GSM) is very wide spread and also in the reach of common man.GSM offers voice call along with short message services (SMS) and General Packet Radio Service (GPRS) for data transfer. India is one of the countries in the world where the charges for mobile communications are very low .Although new smart phones equipped with third generation technology (3G) offers various features related to automotive telematics, safety and security features can also be offered through GPRS technology with much lower cost. The Global Positioning System (GPS) is widely used for various applications like Agriculture, Oceanography, Aviation, Public safety, disaster relief, Mapping etc. GPS was developed by American Department of Defense for military purpose, however later opened for civil use. It is still maintained by US government.GPS technology is the heart of automotive telematics .GPS technology can be used to get the location of the vehicle.

RELATED WORK

All over the world, number of research projects has come up with telematic services for emergency situation. Some popular services are eCall [3], OnStar [4].The eCall is proposed and designed for European Union. In the occurrence of a collision, important information about the location, time etc. will be transmitted and also automatically a voice call will be established with the local emergency number. OnStar is an in-vehicle safety security system by general motors for road side assistance.

The existing emergency services, as discussed above, Need huge infrastructure cost to setup and support the call centers, SMS service providers. In emerging markets like India, these systems do not offer viable solutions. The proposed system transmits minimum set of data (MSD) containing location ,time etc. through GPRS so that the vehicle can be tracked .In case of fence violation or theft SMS alert is sent to the vehicle owner .An alert is also sent to the Database server through GPRS. This system also interacts with other ECUs present in the vehicle through CAN. If the driver is detected under the influence of alcohol it sends an alert and then the ignition of the vehicle gets automatically turned off.

SYSTEM OVERVIEW

The system consists of cooperative components of microcontroller unit (MCU), GPS Receiver, GSM module, CAN transceiver and an alcohol sensor. Fig 1 shows the block diagram of the proposed system.

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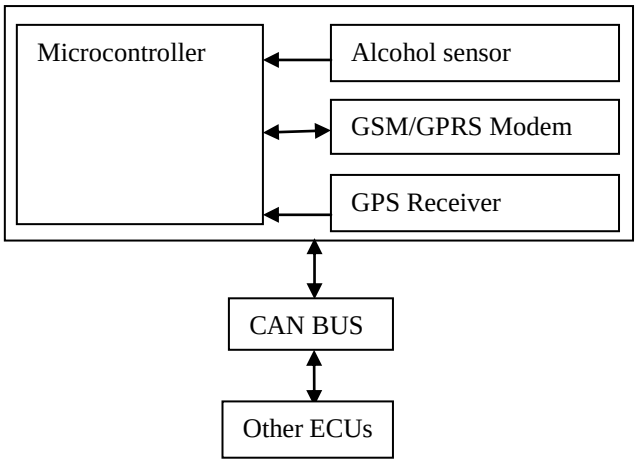

Fig 1: Block Diagram of the proposed Telematics Module

A. GPS Receiver

A very reliable GPS receiver is required to get the accurate information from the GPS satellites. So L10 GPS receiver from Quectel is proposed which gives industry standard MTK positioning information. It supports 210 PRN channels. Even with indoor level signal strength tracking is possible because of 66 search channels and 22 simultaneous tracking channels. Its RF architecture provides immunity to jamming. It also has embedded flash memory for future updates. It is compact and has USB port, UART port for interfacing. The signal acquisition time and start up time is very less: in cold start mode < 35 seconds and in hot start mode < 1.2 seconds. It provides information every 0.5 minutes.

B. GSM/GPRS Modem

The GSM/GPRS modem utilizes the GSM network to send the location of the accident and other necessary information. M10 GSM modem from Quectel is proposed. The M10 is a Quad-Band GSM/GPRS Engine that works at frequencies GSM850MHz,GSM900MHz,DCS1800MHz,PCS1900MHz. It features GPRS multi-slot class 12 and supports coding schemes CS-1, CS-2, CS-3, CS-4.It has unique power saving technology so that in sleep mode it consumes only 1.1mA. It is integrated with internet service protocols. Extended AT commands are also developed for easy internet access. Maximum DATA transfer rate is 85.6kbps both in downlink and uplink. This modem supports all the AT Commands. The modem can be controlled by a microcontroller through AT Command set.

C. Microcontroller Unit

The microcontroller unit (MCU) receives data from the GPS, processes all data, send location of the vehicle to server and vehicle owner/family members. It decides whether the vehicle has crossed its predefined boundary (geo-fence).In case of fence-violation, it sends alert messages to the server and also to vehicle owner. Renessas 78KORFC3is proposed for the system. 78K0RFC3 Microcontroller is widely used in automotive electrical appliances. It has on-chip single power supply Flash memory, on-chip debug function, On-chip power on clear circuit & low voltage detector. It is also capable of self-programming and data protection.

D. CAN Transceiver

78KOR/FC3 micro has an in built CAN controller. The TJA1040 is the interface between the Controller Area Network (CAN) protocol controller and the physical bus. It is primarily intended for high speed applications, up to 1 MBaud, in passenger cars. The device provides differential transmit capability to the bus and differential receive capability to the CAN controller. Transceiver in unpowered state disengages from the bus (zero load). Bus pins are protected against transients in automotive environments.

E. Alcohol detecting sensor

MQ-3 gas sensor (alcohol sensor) is suitable for detecting alcohol content from the breath. So it can be placed on the steering wheel. The surface of the sensor is sensitive to various alcoholic concentrations. It detects the alcohol from the rider's breath; the resistance value drops leads to change in voltage. Also it has a long life with low cost.

DATA ACQUISITION & REPORTING METHODOLOGY

A. Location Details from GPS

GPS receiver provides location information at every half minute. GPS receiver communication is defined by National Marine Electronics Association (NMEA) specification [5].L10 supports NMEA standard 3.01.NMEA sends 8 different types of sentences which are self contained. For the present application GPGGA sentence is most suitable. It contains all the information to find accurate 3D location of the vehicle. A GPGGA has following message format:
$GPGGA, time (hhmmss.sss), Latitude (ddmm.mmmm), N or S, Longitude (dddmm.mmmm),E or W, Fix status, Number of SVs, HDOP, Altitude, M, GeoID separation, M, DGPS age, DGPS station ID, *, Checksum<CR><LF>; Where
hhmmss.sss: is time in hours, minutes, seconds and fractions of second in Coordinated Universal Time (UTC).
ddmm.mmmm: latitude in degrees, minutes and fraction of minutes.
N or S: "N" indicates North and "S" indicates South hemisphere.
dddmm.mmmm: longitude latitude in degrees, minutes and fraction of minutes.
E or W: "E" indicates the East and "W" indicates the West.
Fix status: It is indicated by a number (0 to 5) which tells about the type of satellite fix.
Number of SVs: I indicates number of satellites locked.
HDOP: it indicates horizontal dilution of precision
Altitude: Altitude in meters
GeoID separation: it indicates the height from mean sea level in meters
DGPS age: age of Differential global positioning data in seconds, empty if DGPS not used. DGPS station ID: ID of DGPS station, empty if DGPS not used.
<CR><LF>: indicates beginning of a new sentence

These data from Quectel L10 GPS receiver can be transmitted to microcontroller via universal asynchronous receiver transmitter (UART).From the GPGGA sentence location information can be extracted by counting number of comma(,) by microcontroller. One memory space will be for

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the time, another for the latitude and another for longitude. These values are updated in every 0.5 seconds.

B. Reporting Methodology

Microcontroller sends all these information to a server every half minute to a server via GPRS through the GSM modem.

The GSM modem is initialized. To transmit the location details either SMS service or GPRS can be used. Since the data charges are much cheaper than SMS, GPRS is selected as the primary medium of information delivery. However, in case of any trouble with GPRS, information can also transmitted through SMS.M10 GSM modem can be set accordingly via AT commands to communicate with Server via GPRS, devices connect to each other to transmit data between them and communicate with each other using the TCP/IP (Transmission Control Protocol / Internet Protocol).Through AT commands internal TCPIP stack are created and TCP sessions are established. For the present application one GPRS context is activated to connect with single server in Non-transparent mode. Establishment of TCPIP session is faster and more reliable in Non-transparent method. Location information stored in memory is transmitted to the server via one TCP session. Then the memory locations are updated with the latest location information. A middleware is written to interpret the GPRS data and SMS. This information in the server is used to show the vehicle location on Google Map. So the vehicle can be continuously tracked. Using Geo-Fence algorithm described below, MCU continuously evaluates the status of fence violation. If the vehicle violates its fence limit then CAN messages are sent to other ECUs in the vehicle to lock the vehicle doors and vehicle speed can also be controlled.

At the same time alcohol level can be sensed by MQ3 sensor and then it is compared with the standard level of alcohol. The illegal consumption of alcohol during driving is 0.08mg/L as per the government act. If the driver is found with alcohol in his breath, an SMS alert “Drunken driving” along with the location details is sent to the registered phone numbers in the data base .And also the alert message is transmitted to server through GPRS. After sending the drunken driving alerts, the ignition is also turned off.

C. Geo-Fence Algorithm

Based on requirement Vehicle user can set a reference location by pressing the button on the telematics module. The reference location will be stored in the memory as long as the button is pressed again. A boundary limit (Fence Limit) is set in terms of meters. The location data from GPS is continuously updated and store in the memory space. The location information stored in memory is continuously compared with the reference location.GPS location information is converted in terms of meters and distance between current location and reference location is calculated. If the distance calculated exceeds the boundary limit an alert message is transmitted through the GPRS to Server and also alert SMS is sent to the vehicle owner’s phone number. Alert SMS /alert message contains present location of the vehicle and it informs that boundary limit is violated.

The process to indicate the fence status involves a lengthy calculation. The most challenging work is the conversion of degrees, minutes & second to meters. The existing methods like Haversine Formula gives great circular distance but the lengthy calculations associated with trigonometric conversions slow down the performance. Vincety’s algorithm gives very accurate result. As this is an iterative algorithm, the calculation process is very lengthy. Hence on alternative algorithm is proposed to improve the performance of the microcontroller and which also gives satisfactory result. Table 1 and Table 2 show the detailed distance calculation methods for the proposed geo-fence algorithm.

Table 1: Distance Calculation for Latitude

Change in latitude	**Distance in meters ≈**	**Max change in one decimal place**	**Max distance change corresponding to one decimal place≈**
$0.0001^{'}$	0.184	$0.0009^{'}$	2
$0.001^{'}$	1.84	$0.009^{'}$	17
$0.01^{'}$	18.4	$0.09^{'}$	166
$0.1^{'}$	184	$0.9^{'}$	1656
$1^{'}$	1840	$9^{'}$	16560
$10^{'}$	18400	$50^{'}$	92000
1^{0}	110160	9^{0}	991440
10^{0}	1101600	90^{0}	9914400

Table 2: Distance Calculation for Longitude

Change in longitude	**Distance in meters≈**	**Max change in one decimal place**	**Max distance change corresponding to one decimal place≈**
0.0001’	0.181	0.0009’	2
0.001’	2	0.009’	16
0.01’	18	0.09’	163
0.1’	181	0.9’	1629
1’	1805	9’	16245
10’	18050	50’	90250
1^{0}	108299	9^{0}	974691
10^{0}	1082990	90^{0}	9746910
100^{0}	10829900		97469100

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Proposed algorithm is based on the concept of nautical mile. One minute of arc of latitude measured along any meridian, or about one minute of arc of longitude at the equator is 1,852 meters[6]. However, this arc is dependent on the latitude and longitude of a particular area. In India, one minute of arc of latitude is 1840 meters (average). Table-1 represents distance corresponding to different change in latitude. In India, One minute of arc of longitude is equal to 1805 (average). In India latitude varies from 8 degree to 35 degrees. Longitudinal arc distance depends on the latitude value.

An approximation of a longitudinal degree at latitude φ is given by equation (1)

$$\frac{\Pi}{180}\alpha cos\beta \qquad (1)$$

$$tan\beta = \frac{b}{a}\tan\varphi \qquad (2)$$

Where Earth's equatorial radius α equals 6,378,137 m and relationship between β and φ is given by equation (2); [7] for the GRS80 and WGS84 spheroids, b/a calculated to be 0.99664719.Aside from rounding, this is the exact distance along a parallel of latitude.

Fig 2 shows the flowchart to detect the fence violation status.

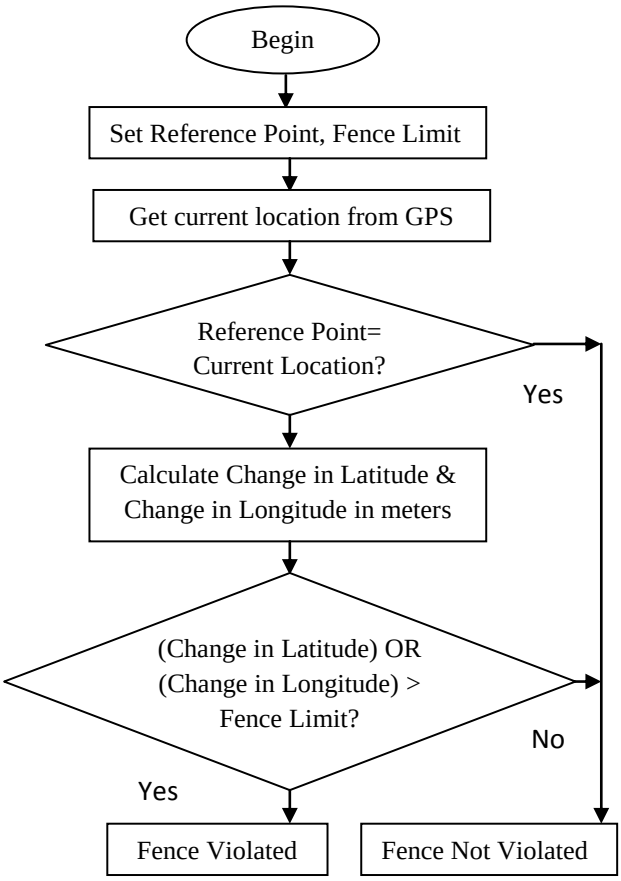

Fig 2: Check Fence violation status

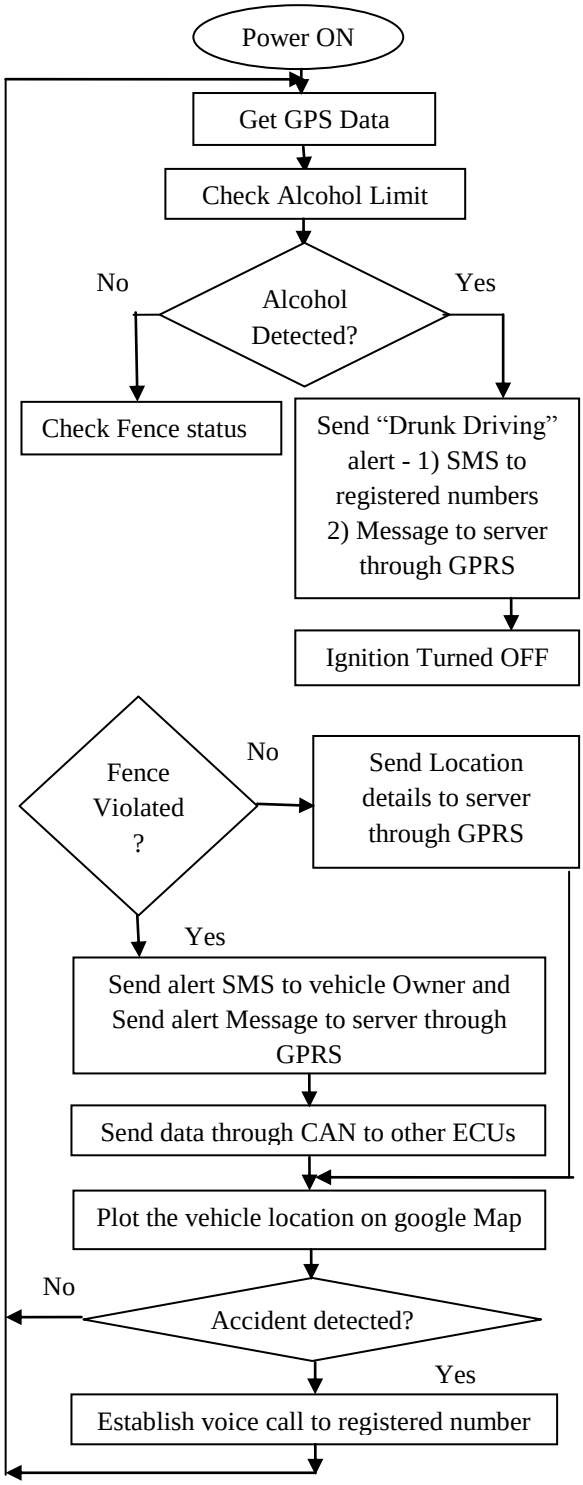

Fig 3: Operation of Telematics Module

Fig 3 shows the overall function of the proposed telematics module.

Proposed Geo-Fence algorithm gives appreciable results which is comparable with the conventional algorithms. Accuracy of the algorithm depends on the value of Fence Limit. Percentage Error is in direct proportion with the value of Fence limit. However, in all circumstances the maximum error is limited to 0.005percentage of Fence Limit.

Once Fence violation is detected, Alert SMS and messages are sent through GSM and GPRS respectively and the location can be tracked on the Google Map.

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In these circumstances vehicle can be controlled remotely. The future work is to control the Speed as well as ignition remotely.

CONCLUSION

GPS Receivers Play a very important role to provide timely aid in case of emergency like accidents, theft or Fence –violation to detect the exact location of the vehicle. With GPS receiver's vehicle driven by drunken drivers can be located. After detection of drunken driving, it sends the location of the vehicle and then the ignition is turned off. Thus probable accidents can be avoided and driver can also be traced. The proposed system reduces the infrastructure cost. This self contained system is able to send alert SMSs, it also communicate with the server through GPRS to track the vehicle. Its operational cost is also minimal, making it suitable for developing countries like India. Thus, the proposed system can help the People by providing essential safety and security features economically.

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