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Intelligent Vehicle Tracking and Accident Prevention Technology with Anti Theft Mechanism

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***Abstract*— The Vehicle tracking system is a total security protection and fleet management solution. By using the latest GSM & GPS technology to protect and monitor our car, truck and any other moveable object virtually anywhere and then locate it within a few meters. This Paper presents an automatic vehicle accident detection system using GPS and GSM modems with the help of piezoelectric sensors and snap action switches which can detect the accident when ever any vehicle or object collides with the vehicle. The system can be mounted with the control system of the car and aware the owner about the location of accident on his mobile phone using GPS and GSM. The system gives the location of the vehicle upon sending a message in case it has been theft. This system also provides an accident prevention using sensors which upon detection of any obstacle can reduce the speed of the vehicle and prevent the accident. The proposed design demonstrates the feasibility of real time tracking of vehicles and enhanced customizability, global accessibility and economical in contrast with existing designs.**

Keywords*— *GSM (Global System for Mobile Communication), GPS (Global Positioning System), Vehicle Tracking, Accident prevention.

I. INTRODUCTION

Automatic Vehicle Location (AVL) is a system that provides vehicle tracking service and is often used by fleet operators to follow the movements of their vehicles. This system is based on Global Positioning System (GPS) where communication with satellites is used to get the coordinates of an object among other vital information [1]. The proposed prototype is designed and develops to accommodate the needs of modern world to keep track on their vehicles in case of theft or accident condition. It is a very useful and resourceful device, and in fact it can be used by anybody with the need to keep track on their valuable commodities and not only by the vehicle fleets company. The required output from the system will be the data such as pace, location, and point in time obtained from the GPS receiver and will be displayed on the LCD and phone. The global number of vehicles is expected to increase as ownership becomes more affordable due to the growing economies of countries such as China and India [2]. However, the adoption of vehicle tracking system is still very much lacking. Such a system can be used for many applications including security of personal vehicle, public transportation systems, fleet management and others. Vehicle tracking systems have been available in the market for some time but they are application specific, region specific and are costly [3-4]. Therefore a system designed for car security will not be suitable for fleet management [5]. It is envisioned that the proposed system will be easily customizable for various applications. The proposed system can be used globally and is expected to be economical. Fig 1 shows the basic functionality of the tracking system.

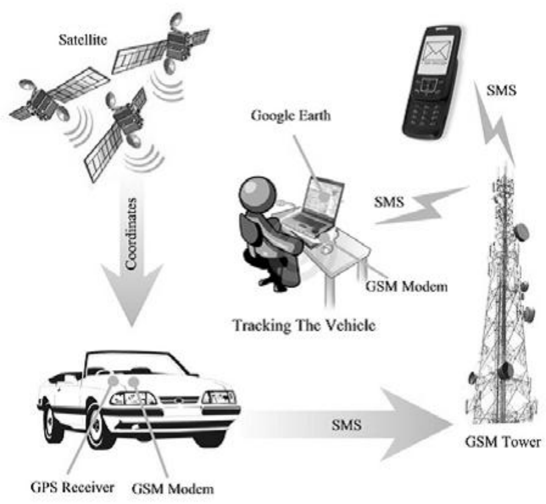


Fig 1: Basic functionality of tracking system

II. GLOBAL POSITIONG SYSTEM (GPS)

GPS is a real-time satellite navigation system for three dimensional position determinations. It was developed by several U.S government organizations, including the Department of Defence (DOD), the National Aeronautic and Space Administration (NASA), and the Department of Transportation (DOT). GPS has three parts: satellite constellation, ground-control/monitoring network, and user receiving equipment. The satellite constellation is the group of satellites in trajectory that endow with the ranging signals and information messages to the user paraphernalia. The control segment oversees and maintains the space segment which is the satellite constellation in space. The user segment, or the user receiver equipment, receives the signal from the space segment and computes the navigation, timing and other functions [6].

A. Kalman filtering Algorithm for GPS Co-ordinates

A Kalman filter is used to correct factors influencing the accuracy of position determination include: satellite geometry, shifts in the satellite orbits, clock errors of the satellites' clocks, tropospheric and ionospheric effects and calculation errors [7]-[8]. The filter is used to reduce GPS errors and thus increase the accuracy of the localization system [9]-[10]. In a GPS measurement system [*Sxi Syi Szi*] refers to *i*th satellite coordinates, [*Gx Gy Gz*] indicates GPS receiver coordinates and *Ri* represents satellite range as [*Sx-Gx Sy-Gy Sz-Gz*]. Also, pseudo range *PRi* is defined as [11]-[12].

$$\boldsymbol{PR_i} = \sqrt{(\boldsymbol{S_{xi}} - \boldsymbol{G_x})^2 + (\boldsymbol{S_{yi}} - \boldsymbol{G_y})^2 + (\boldsymbol{S_{zi}} - \boldsymbol{G_z})^2} + \boldsymbol{b_u} = |\boldsymbol{R_i}| + \boldsymbol{b_u} \quad (1)$$

Where b_u is receiver clock offset error

The state vector x of the system at time k+1 are produced by:

$$\boldsymbol{x_{k+1}} = \emptyset_k \boldsymbol{x_k} + \boldsymbol{w_k} \quad (2)$$

Where $\emptyset_k$ is the state transition matrix. The noise $\boldsymbol{w_k}$ is white Gaussian noise with zero mean and covariance $\boldsymbol{Q_k}$. The state vector is defined as :

$$\boldsymbol{x} = [G_x \;\; G_y \;\; G_z \;\; b_u]^T \quad (3)$$

Where $[G_x \;\; G_y \;\; G_z]$ GPS receiver coordinates indicates, b_u is receiver clock offset error. The state transition matrix $\emptyset_k$ is an identity matrix of 4x4. The process measurement is defined as:

$$\boldsymbol{Z_k} = \boldsymbol{H_k x_k} + \boldsymbol{v_k} \quad (4)$$

Where $\boldsymbol{H_k}$ is measurement matrix and noise $\boldsymbol{v_k}$ is assumed to be Gaussian with covariance matrix $\boldsymbol{R_k}$. $\boldsymbol{v_k}$ has zero cross correlation with $\boldsymbol{w_k}$.

The GPS receiver measurement vector for ith satellite includes the pseudo range **PRi=|Ri|+bu** as in (1).
Linearization of the satellite range **|Ri|** about estimated GPS Receiver coordinates, we find:

$$|\boldsymbol{R_i}| = \sqrt{(\boldsymbol{S_{xi}} - \boldsymbol{G_x})^2 + (\boldsymbol{S_{yi}} - \boldsymbol{G_y})^2 + (\boldsymbol{S_{zi}} - \boldsymbol{G_z})^2}$$

$$\approx \frac{-(s_{xi} - G_x)\widehat{G_x}}{|R_i|} + \frac{-(s_{yi} - G_x)\widehat{G_y}}{|R_i|} + \frac{-(s_{zi} - G_z)\widehat{G_z}}{|R_i|} \quad (5)$$

Therefore the measurement vector is :

$$\boldsymbol{H_k} = \left[\frac{-(s_{xi} - G_x)}{|R_i|} \;\; \frac{-(s_{yi} - G_x)}{|R_i|} \;\; \frac{-(s_{zi} - G_z)}{|R_i|} \;\; \boldsymbol{1}\right] \quad (6)$$

The procedure is initiated by the assumption of $\boldsymbol{x_0^-}$ and $\boldsymbol{p_0^-}$: initial estimate of states and its error covariance respectively. The optimal Kalman gain $\boldsymbol{K_k}$ is utilized to achieve the update estimate of the pseudo range measurements $\boldsymbol{\hat{x}_k}$ and its error covariance $\boldsymbol{P_k}$ as:

$$\boldsymbol{K_k} = \boldsymbol{P_k^- H_k^T}[\boldsymbol{H_k P_k^- H_k^T} + \boldsymbol{\hat{R}_k}]^{-1} \quad (7)$$

Then the update estimate with measurement $\boldsymbol{Z_k}$

$$\boldsymbol{\hat{x}_k} = \boldsymbol{\hat{x}_k^-} + \boldsymbol{K_k}(\boldsymbol{Z_k} - \boldsymbol{H_k \hat{x}_k^-}) \quad (8)$$

The error covariance is computed as:

$$\boldsymbol{P_k} = (\boldsymbol{1} - \boldsymbol{K_k H_k})\boldsymbol{P_k^-} \quad (9)$$

The next state $\boldsymbol{\hat{x}_{k+1}^-}$ and error covariance $\boldsymbol{P_{k+1}^-}$ is then calculated based on the current state estimate as in (10) and (11).

$$\boldsymbol{\hat{x}_{k+1}^-} = \emptyset_k \boldsymbol{\hat{x}_k} \quad (10)$$

$$\boldsymbol{P_{k+1}^-} = \emptyset_k \boldsymbol{P_k} \emptyset_K^T + \boldsymbol{\hat{Q}_k} \quad (11)$$

The figure shows 3D positioning of GPS coordinates based on Kalman filtering algorithm

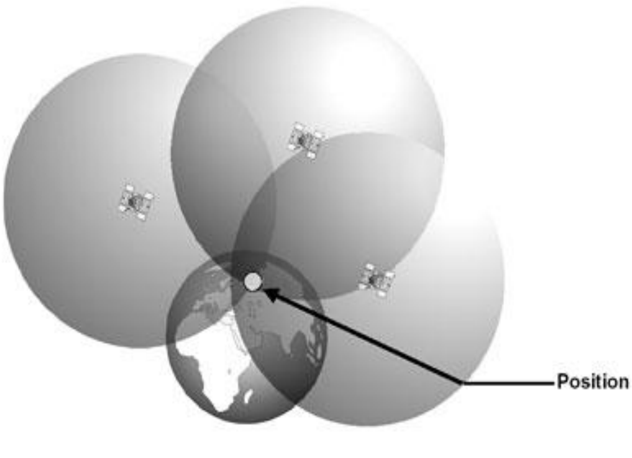


Fig2: 3D positioning of GPS coordinates

The GPS accuracy is measured using **2DRMS** (Twice Distance Root Mean Squared). The computation of **2DRMS** is attained by:

$$2DRMS = 2\left(\sqrt{\sigma_x^2 + \sigma_y^2}\right) \quad (12)$$

Where σx, **σy** are the standard deviations of latitude and longitude respectively of the estimated coordinates by Kalman filter.

III. GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)

The Global System for Mobile Communications (GSM) is the second-generation digital cellular mobile network [13]. It is widely deployed around the world. Although improvements to GSM such as the next generation systems have been rolled out to cater for faster data centric traffic, backward compatibility to GSM is still maintained. Due to its wide availability, it is chosen as the medium for transfer of location information. The simple and inexpensive Short Message Service (SMS) allows users to send up to 160 characters. For the purpose of this project, the SMS is more than sufficient for sending the location information. GSM selected a amalgamation of TDMA/FDMA as its method. The FDMA element consists the division by frequency of the entire 25 MHz bandwidth into 124 carrier frequencies of 200 kHz bandwidth. The frequency range specified for GSM is 1850-1900 MHz figure shows the block diagram of GSM architecture.

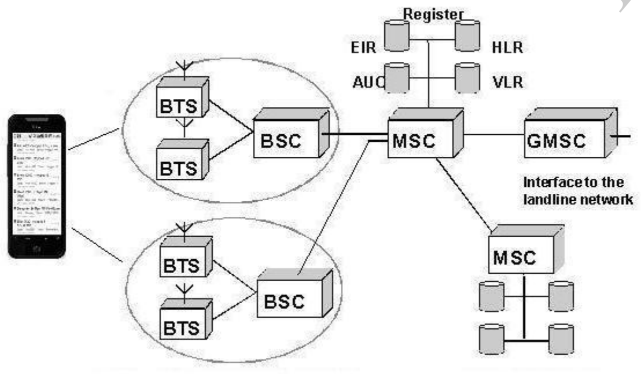


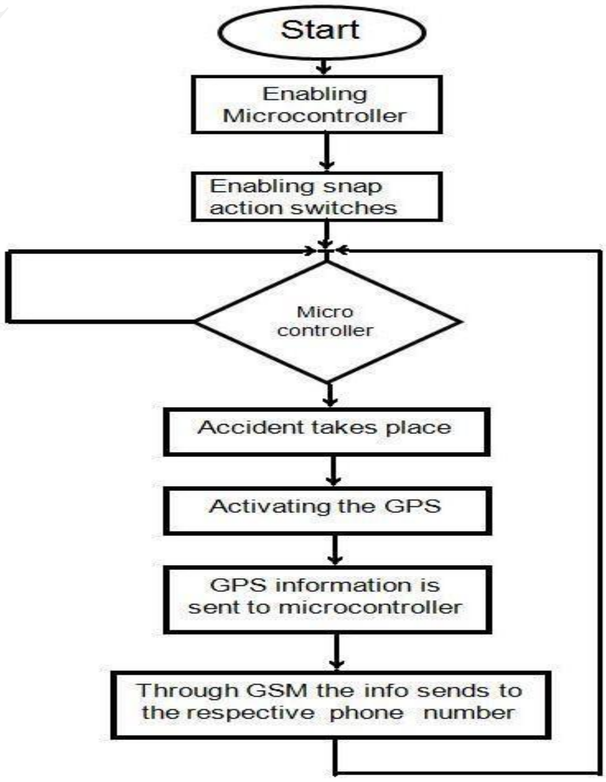
Fig 3: Block Diagram of GSM architecture

IV. SYSTEM OVERVIEW

The system has two main blocks; the first block is the tracking device which is mounted on to the vehicle. This block consists of a Microcontroller, GPS receiver and a GSM Modem. The Microcontroller performs 3 basic operations: to receive values from some electronic sensors connected to automobile data port such as piezo electric sensors and snap action switches, to perform processing of the GPS data to extract preferred coordinate values and to transmit this information to the workstation PC server using GSM modem by AT commands. The GPS Receiver gets the coordinates information from satellites in the form of real-time latitude and longitude values.

The second block consists of a receiver GSM modem and workstation server PC. The recipient GSM modem can be a mobile phone or a GSM receiver connected to workstation server PC. The modem gets the SMS through AT commands that include sensor parameters and GPS coordinate values. The data is passed through a Visual Basic program in order to gain the numeric parameters, which are stored in as a CSV file. The obtained values of the GPS coordinates are further improved by our database record. To transmit this parameter values to Google Earth, the CSV file is converted to KML (Keyhole Markup Language) file which is supported by Google Earth. Google Earth reads KML file, extract the desired information about location and shows automobile's location engine parameters on the Google earth map. The system's effectiveness is reliable on the sufficiency of the used communication system. A supplementary setting could be implemented to interconnect the device to the car's alarm to aware the owner on his mobile phone in case if the alarm is turned off. Immediately alert to phone number which gives location of our object (automobile).

The basic flowchart for the proposed system is described below:



Flowchart 1: Accident Detection

The accident prevention module attached to this system is an added advantage which gives extra safety to the vehicle. In this module, we have connected the IR sensors on all the sides of the vehicle which sends the IR rays continuously and upon detection of any obstacle, stops the vehicle which is controlled by a micro controller.

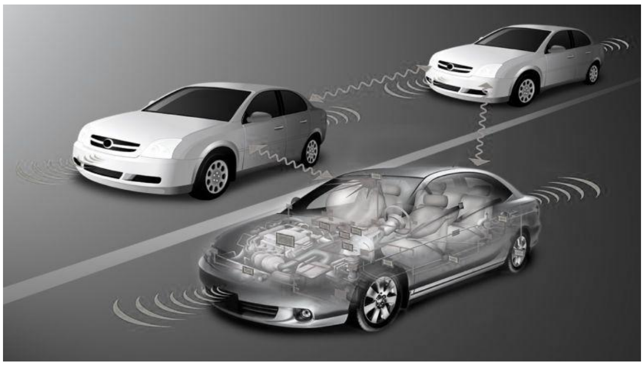
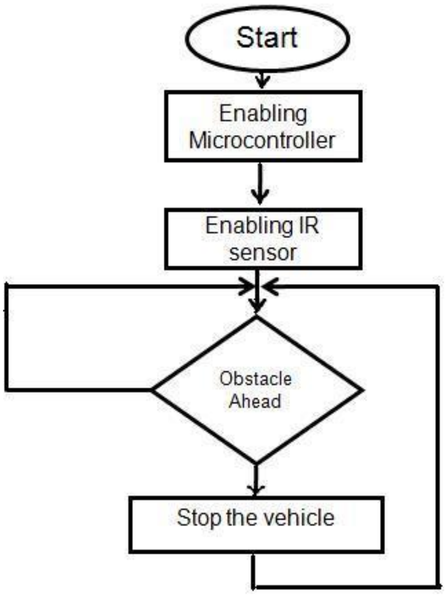


Fig 4: Working of Accident Prevention system

The basic flow diagram is shown below.



Flowchart 2: Accident Prevention

A. HARDWARE SPECIFICATION

The tracking device consists of two main inputs: The first received input is the out of GPS receiver , which has its model as NMEA 0183 standard. The other input is obtained by the sensors connected to the automobile. The unit sends an SMS through GSM using Hayes commands (AT-Attention Commands).

Infrared radiation is the portion of electromagnetic spectrum having wavelengths longer than visible light wavelengths, but smaller than microwaves, i.e., the region roughly from 0.75µm to 1000 µm is the infrared region. The model of GSM modem is SIM900D, this module supports standard AT Hayes commands and companionable with several GSM networks.

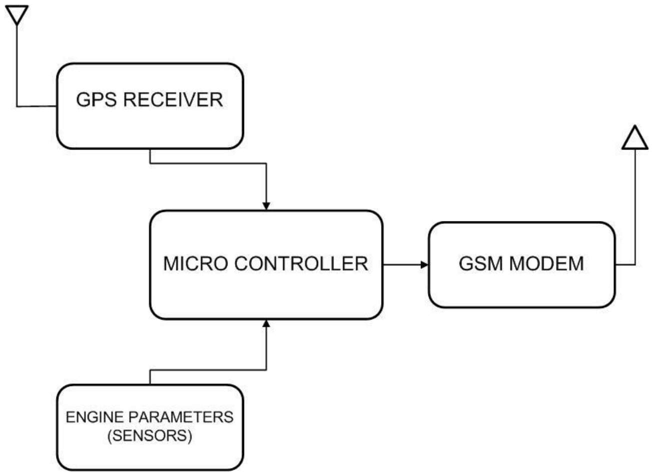


Fig5**:** Block diagram of Tracking System

Transmission parameters are set to: Uplink freq: 1710-1785 MHz, Downlink freq: 1805-1880 MHz, Transmission rate=270kbps, Frame duration=4.61ms, Baud rate= 9600 bps with zero flow control.

The GPS receiver model is Mediate MT3329. It supports up to a frequency rate of 15Hz. The microcontroller unit is the key working unit of the tracking module. The GPS receiver receives the coordinate information in the form of latitude, longitude and speed data values and sent them to the microcontroller unit. The GSM modem communicates with the microcontroller to send the information about coordinates to receiver end GSM Module at the Work station PC, all the data can be viewed on Google Earth after being processed. Figure shows the external view of the tracking unit. The tracking device is designed to be auto powered by the vehicle battery. However, a battery source is built-in the unit in case of any emergency for backup.

B. SOFTWARE SPECIFICATION

In this tracking design we have worn Google Earth software for tracking the current status of the vehicle. Google Earth presently supports the majority of GPS devices. The proposed GPS Module has TCP/IP or UDP Protocol for transferring GPS data to a Workstation server PC. This etiquette consists of several sentences, starting with the character $, with a max of 89 characters in piece. The NMEA Message to read information with both site and point in time is therefore, only the $GPRMC data is used to determine the position of the automobile to minimize SMS content. The status of the vehicle along with $GPRMC data is sent by the GSM transmitter modem. Subsequently, the receiver GSM module, also has TCP/IP or UDP etiquette, receives the sent SMS to obtain GPS coordinate values and condition of the vehicle.

The transferred GPS information is processed by a Visual Basic software program using a Kalman filter to correct the existing position and update it accordingly. The resulted data of corrected position and vehicle condition is saved in an CSV file. The CSV file is exported to a KML file format that is attuned with Google Earth. Figure gives the block diagram of the receiver module in the system.

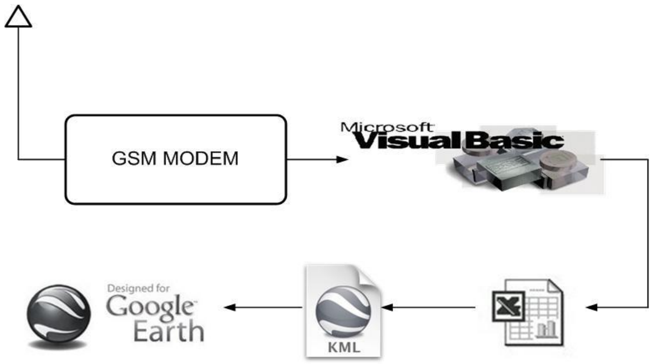


Fig6: Block diagram of the recipient module in the system

Hence, Google Earth will view the position and condition of the vehicle on the map by evaluation of the KML format file. The KML format file, developed for Google Earth, is used to hoard geographic information that includes maps driving instructions and Navigation information. Figure shows the current position of a vehicle in terms of longitude and latitude.

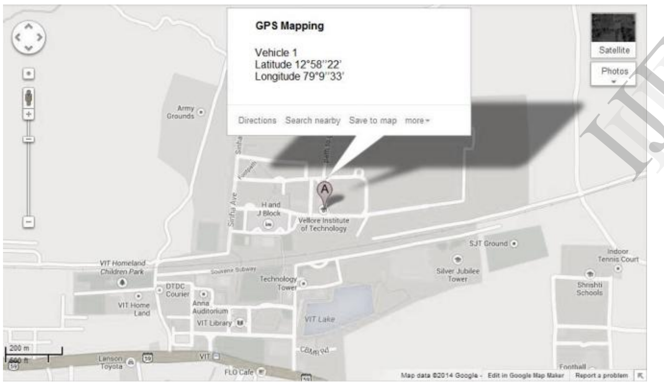


Fig7: Google Earth mapping

In addition, Google Earth also has the ability to track an entity and show the related information at any place as shown in figure. The track shows the travelled sites of the vehicle form the commencement of the route. All data is stored in a separate CSV data sheets.

V. CONCLUSION

In this paper we try to establish the futuristic technology for better mankind by employing latest GPS and GSM based fleet management system using TCP/IP or UDP protocol with the assistance of microcontroller real-time vehicle tracking solution via Google Earth. The proposed system has many benefits such as large competence, wide area range, cost effective and friendly to use in vehicle traffic organization. The system included two main components: a transmitting embedded device to interface in-vehicle GSM and GPS modules in order to determine and send vehicle current location and vehicle condition through SMS. The second stationary module is a recipient module to receive and process the transferred data to a attuned format with Google Earth to continuously monitor the vehicle location and status online. The two added advantages of tracking the vehicle in case of theft and preventing the vehicle from accident using sensors make this system more reliable. The transmitted position of the vehicle has been filtered using Kalman filter to achieve accurate tracking. The precision of filtered coordinates is pragmatic to be less than 25 meters in contrast with 65 meters for transmitted coordinates received by vehicle mounted GPS module.

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