Efficient and Cost Effective Vehicle Tracking and Security System Using Global Positioning System

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Abstract— The rate of vehicle theft all over the world is alarming and there is need to curb the act. There are different vehicle alarm and security systems with one or more limitations. In this paper, a low cost and efficient vehicle tracking and security system using Global Positioning System (GPS) is developed. The system consists of a hardware device (in-vehicle unit) installed in the vehicle to be tracked and a user/control phone. The device receives signal from the GPS satellites, send this data to the authorized user's phone by Short Message Service (SMS) with the help of the Global System for Mobile communication (GSM) module placed in the device. The data that is been sent to the control phone is processed and fed into a Geographic information System (GIS) interface for the graphical location information display. The developed system also has the ability of stopping and starting the car by the connected relay when codes in form of SMS are sent to the in-vehicle unit from the authorized user of the system. The test results show that, the developed system is highly accurate and effective in determining location of vehicle and it is of high performance.

Index Terms— Geographic Information System, GPS, GSM Module, Mobile Station, SMS, Microcontroller

1 INTRODUCTION

THE need to nip in the bud the menace of vehicle theft in our society is of great importance all over the world. There are different vehicle alarm systems which when the alarm triggered, the owner could be alerted. Apart for the fact that these types of alarm systems are limited to certain distance, the driver might not have the opportunity of setting other associated security measures that can prevent the vehicle from being stole when attacked at gun point. This shows that most of the conventional vehicle security systems are ineffective in handling advanced way of theft [1].

A vehicle tracking system is an electronic device installed in a vehicle to enable the owner or a third party to track the vehicle's location. There are technical terms that can be used that specify the ability to determine the location of a mobile station (MS) such as Geolocation, position location and radiolocation. By location, we mean the coordinates of the MS that may be two or three dimensional. This also comprises information such as the latitude and longitude where the MS is located [2]. There are certain companies that have the required technology in vehicle tracking but their subscribers have to pay for the services rendered monthly which make it highly expensive for majority to subscribe to. To this end, there is need for an efficient and cost effective vehicle tracking and security system. This paper presents a low cost vehicle tracking and security system that requires little or no maintenance. It can be operated by the owner of the vehicle and there is no need for monthly charges by the third party. The proposed system can transmit the location information of the vehicle when requested for or at certain pre-set period. Although the system can operate in real time but it is not implemented to save charges from service provider.

The device consists of a hardware device (In Vehicle Unit) installed in the vehicle to be tracked and a user/control phone. The device receives signal from the GPS satellites, send this data to the user's phone by SMS with the help of the GSM module placed in the device. The data that is been sent to the user/control phone is processed and fed into a GIS interface (Google Map Application).

In Section 2, literature review on vehicle tracking system is discussed. Section 3 presents the system overview, design and methodology. Section 4 contains the performance evaluation, result and analysis. Conclusions are drawn in Section 5.

2 BACKGROUND

In a conventional vehicle tracking system, location is determined the use of GPS. There is need for communication channel from and to the control unit where location information can be access. The transmission mechanism could be a satellite, terrestrial radio or cellular connection. After capture, the tracking data can be transmitted using any choice of telemetry or wireless communications systems. GSM is the most common used service for this purpose. The received data by the control phone can be processed and fed into a GIS interface [3].

2.1 Global Positioning System (GPS)

The Global Positioning System (GPS) is a space-based global navigation satellite system that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver. GPS consists of a network of 24 satellites in six different 12-hour orbital paths spaced so that at least five are in view from every point on the globe [4].

2.2 Geographic Information System (GIS)

A geographic information system (GIS) is any system that captures, stores, analyses, manages, and presents data that are linked to location. In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology. GIS systems are used in systems such as cartography, remote sensing, navigation, and localised search engines [2, 5].

2.3 Microcontroller

Microcontrollers are mini computers on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. They are designed for embedded applications, and also used for automatically controlled devices [4, 6].

2.4 GSM Module

A GSM module is a wireless module that works with a GSM wireless network. A wireless module behaves like a dial-up module. The main difference between them is that a dial-up module sends and receives data through a fixed telephone line while a wireless module sends and receives data through radio waves [3, 7]. GSM module is connected to a computer through a serial cable or a USB cable.

3 System Overview

The tracking device is installed in a vehicle, and has the capability to receive both GPS and GSM signals via GPS receiver and GSM module respectively. The GPS receiver gets the exact current position of the vehicle in form of longitudinal and latitudinal coordinates from any four visible satellites among the constellation in the orbit [2, 8]. These positional data is then displayed on the device's LCD and sent to the control/user phone in form of SMS via a communication network when it is been requested for, this interaction is possible because of the GSM module in tracking device. The tracking device is triggered when a specified SMS is received requesting its current location information.

Furthermore, the relay on the tracking device could be de-energized by an SMS from the control phone thereby cutting off the flow of fuel from the vehicle hence the vehicle stops when it has been confirmed that there is a theft. The device confirms this action by sending a confirmatory 'CAR OFF' text to the control phone. To energise the relay again an SMS from the control phone will enable flow of fuel and the vehicle can operate again. The device also confirms this action by sending a confirmatory 'CAR ON' text to the control phone.

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The positional data gotten from the tracking device is been converted to degree-minutes-seconds (DD MM SS) by a MATLAB program and this is been fed into a Google map application where the vehicle exact position can be viewed. The system is illustrated in fig. 1.

Fig 1: Overview of Vehicle Tracking System

3.1 System Design and Methodology

The GPS module used for this work is the ME2530A module. It is an antenna-less receiver and it is employed because it does not require an external GPS antenna. Its in-built antenna makes the tracking device more reliable and compact. The microcontroller used is the ATmega16. Two of these microcontrollers are interfaced together. In this vehicle tracking, the embedded microcontroller is programmed to be able to read and interpret SMS been sent to it by a phone or a GSM module in form of codes.

The GSM module serves as the communication link between the GPS vehicle tracker and the control phone. It communicates by sending SMS to the control phone and also acts as a recipient in receiving SMS from the control's phone. The GSM module in the system comprises of a SIM slot, where a SIM card is inserted; an antenna, for reception and a serial I/O port: for connecting to other serial devices as well as programming. In this project the GIS used is the Google Map Application which translates the longitudinal and longitudinal coordinates into pictorial view. The major components here include; two microcontrollers (ATmega16), GSM module, GPS receiver.

4 Performance Evaluation, Result and Analysis

The tracker works effectively when energised for operation. The device loads for some seconds while it tries to receive and read the GPS signal. After connection with the GPS has been established, the device reads the information and displays its current position on the screen. This is shown in plate 1. The tracker current location is shows in longitudinal and latitudinal coordinates.

Plate 1: Device showing its current position

When the tracker passes the initialization stage of retrieving and reading the GPS signal it sends a message to the control phone prompting the user on what to do. The message contains the command code that the device recognizes. The control phone used for the project was a Blackberry Curve 3 phone. Although other phones can be used as the control phone because it functions with the mobile number of the SIM card which has been included in the source code. Plate 2 shows the format the SMS sent to the control's phone.

Plate 2: SMS Format Sent to the Control Phone.

From plate 2, messages like "**Car Tracking System Ready: send DATA to get location, CAR OFF to disable the car, CAR ON to enable car"** are received by the control phone. When **"DATA"** is sent to the tracker's number, the exact position of the device present location is returned to the control phone as:

"Car location 1030.1846, N 00726.0841, E DATA"

Although these are positional coordinates, they are in degree-minutes (DD'MMMM) form, but the GIS employed, GOOGLE MAP API, only recognizes coordinates in degree-minute-second (DD'MM'SS). A MATLAB code is written to do the conversion. A function was written on MATLAB with the M-file. The function for converting the longitude was named CONVLONG that for latitude CONVLAT. The MATLAB interface converting the longitude and latitude is shown in fig. 2.

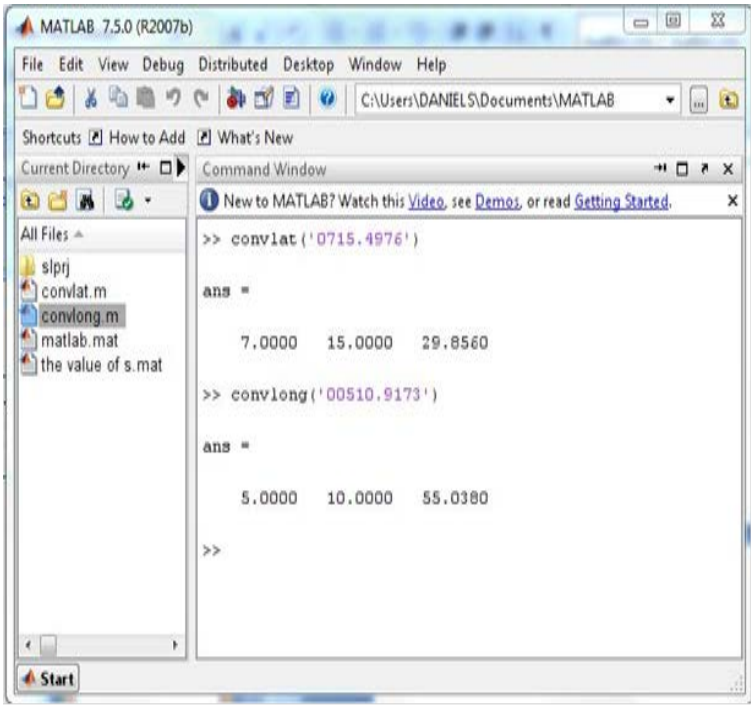

Figure 2: using the CONVLONG and CONVLAT codes

After getting the converted positional coordinates, it is inserted in Google Map as shown in figure 3. The converted latitude value in DD'MM'SS which is usually three separate values e.g. **7 17 43** is first placed in the Google Map search box followed by a space and the converted longitudinal value usually three separate values e.g. **5 8 53** are entered. When this is done, the map interface shown below is obtained. The green arrow shows the location of the exact position of the tracking vehicle.

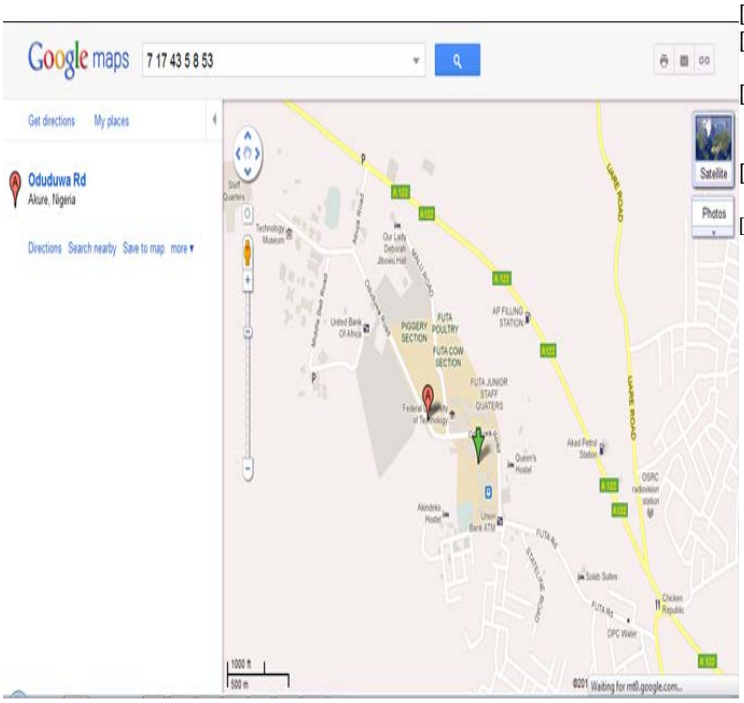

Figure 3: Google Map View of the Vehicle's Locations

5 Conclusion

Vehicle tracking system is becoming increasingly essential all over the world because of alarming theft rate. The paper presents a highly accurate yet inexpensive and effective vehicle tracking and security system using GPS that could be used to track and protect any remote vehicle equipped with the In-Vehicle Unit. The system consists of the In-Vehicle Unit and a Control Phone. The location information is transmitted to authorized user's control phone using GSM modem on GSM network by using SMS. The control phone also has GSM modem that receives vehicle location information via GSM network. When it has been confirmed that there is a theft an SMS from the control phone cuts the engine of the remote vehicle by stopping the flow of fuel hence the vehicle stops. The results presented in this paper contain execution of startup routine, logs of the control phone, converted position coordinates and GIS map of the current location of the vehicle. Performance evaluation of the system shows effective operation.

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