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A GPS/GSM Based Vehicle Monitoring and Anti-Theft System

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Abstract

Aiming at the requirement of remote monitoring and anti-theft system, a GPS/GSM based mobile phone remote vehicle monitoring and anti-theft system is developed. The system design contains two parts: hardware part and software part. On the hardware design, the STC89C52 chip is chosen as the main control chip, the u-blox NEO-6M chip is used as the vehicle position information module, and the GTIM900-B chip is adopted as the short message sending module. On the software design of the system, a single-chip microcomputer program, an analog serial port program, a GPS information processing program and a GSM short message sending program are implemented. In addition, the system has developed algorithms, including map displaying algorithm, speech alarming algorithm and short message trapping algorithm. When an abnormal moving distance exceeds 100 meters, the current vehicle position will be identified and displayed on the APP map of the mobile phone in real time for the vehicle owner, and the system will warning the owner that the vehicle has moved by speech alarming. The system is the low-cost, and can be applied extensively on the remote monitoring of personal vehicle and the remote trapping and location of the outside moving subject.

Keywords*: Vehicle Anti-theft System; GPS; GSM; APP Monitoring*

1 Introduction

Along with the rapid development of the economy and improvement in people's standard of living, private cars have entered the home of ordinary people[]. Given the widespread occurrence of car theft, vehicle location and control techniques have become the research focus [1-6].[1]

Vehicle tracking and monitoring system is implemented by the combination of GPS and GSM networks with an on-vehicle terminal, GSM communication network, and monitoring center. The terminal collects the vehicle speed and location data and then transmits them to the monitoring center by the GSM communication network, which saves these condition data into the database and builds a web server to display the query results, such as real-time vehicle location in a digital map for register personals and institutions. The monitoring center also sends the control commands to vehicles[7-10]. However, the prevalence of tablets and smart phones has driven the development of

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vehicle-monitoring systems in mobile terminals by adopting the Android platform to realize real-time vehicle mobile monitoring and scheduling[11-13].

Most existing GPS vehicle-monitoring systems use GPS only or GPS-based smart phones to collect vehicle location data, which are then transmitted via mobile communication network and saved in a database. On the basis of these condition data, the control instructions are given to the vehicles by the monitoring center. The vehicle running state can only be acquired in the monitoring center. The drawbacks of the system include complicated development, high development cost, and expensive maintenance. A new vehicle anti-theft monitoring and tracking system is presented in this paper. The proposed system sends the vehicle location message to its owner via the GSM network and calls the terminal APP program to display the concurrent position in the digital map. The system provides a voice notification when the car moves to other places. With our new system, the personal user requirement of obtaining vehicle location information at any time can be satisfied.

2. Overall Design of the System

To implement remote monitoring and location tracking by the phone terminal, the system has to perform the collection, processing, and transmission of vehicle location data. Therefore, the overall design of the system includes four parts: main control module, GPS module, GSM module, and mobile phone terminal. The main control module is responsible for processing car longitude and latitude data, identifying car speed, and controlling message transmission. The car location message is received by the phone terminal and displayed on the digital map. At the same time, the car owner will receive the voice notification from the mobile phone to help him or her remotely monitor and track the car. On the basis of the above requirement analysis, the overall system design is shown in Figure 1.

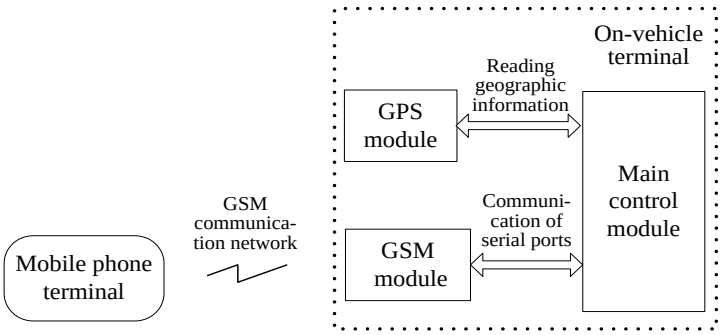

Figure 1. The Overall Design of On-Vehicle Monitoring and Anti-Theft System based on GPS/GSM

3. Overall Design of the System Hardware

The hardware of the on-vehicle anti-theft monitoring and tracking system includes the STC89C52 single-chip microcomputer main control module, UBLOX ATK-NEO-6M GPS module, Huawei GTM900-B GSM module, reset module, power supply module, and mobile phone terminal. The overall hardware design is shown in Figure 2. In the system, the reset module would manually reset the single-chip microcomputer to recover the main control module. The power supply module uses a portable source with a USB to a DC 5.0 v power supply charge cable; this setup benefits mobility and makes the testing convenient. The sending of short messages are managed by the GPS module, which also detects the serial port of the microcomputer to determine whether an AT command exists in the short message and send the command to the car owner’s mobile phone. The phone

terminal is responsible for capturing the vehicle location message, displaying it on the digital map, and providing voice notification.

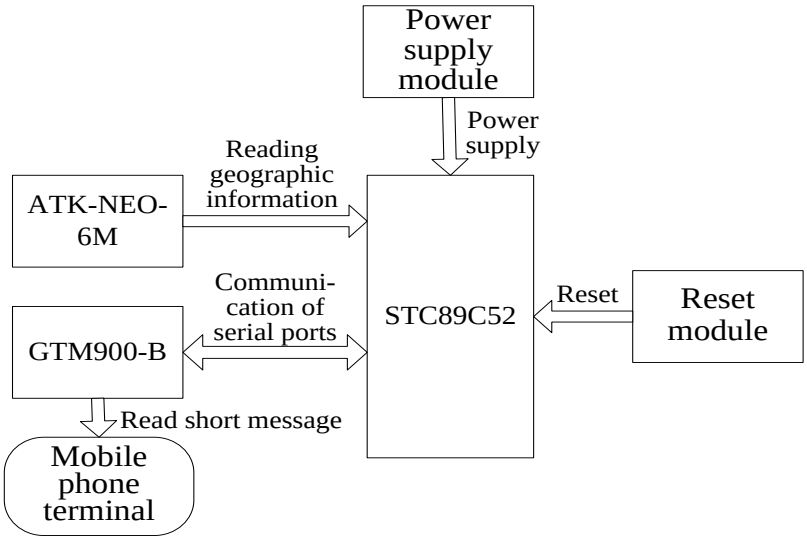

Figure 2. Overall Design of the System Hardware

The circuit schematic of the on-vehicle terminal is presented in Figure 3. The power supply of the microcomputer is provided by J1 via a USB cable, the GPS module is connected to J2, and the GSM module is connected to J3.

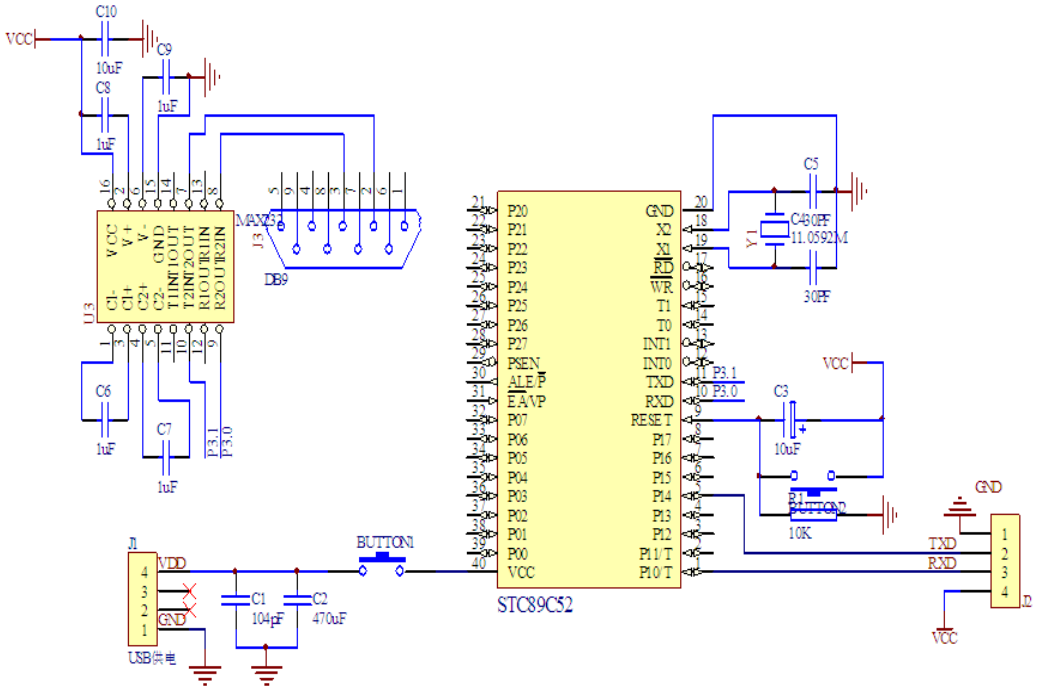

Figure 3. Circuit Schematic of the On-Vehicle Terminal

4. Software Design of the On-Vehicle Monitoring system

4.1 Design of the Main Program

The software design of the on-vehicle anti-theft monitoring system includes the main program, GPS data processing program, GSM short message sending program, and phone terminal APP. The initialization of each module is managed by the main program, which first initializes the GSM module, initializes the serial port and timing device, and finally initializes the GPS module. This process automatically starts in hardware mode after powering up. The system then commences location data collection and processing. Alarm information, such as location data, would be sent to the car owner when the car moves out of the specified area at a certain speed. These procedures will loop continuously. The flow chart of the main program is shown in Figure 4.

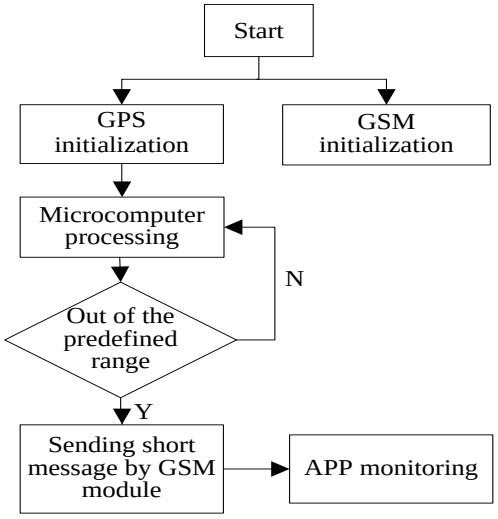

Figure 4. Flow Chart of the Main Program

4.2 Receiving and Processing of GPS Location Data

GPS positioning and navigation information is received, processed, and sent to the microcomputer module by the GPS module on its operating state. These GPS data are in $GPMRC format. The original latitude and longitude data of the vehicle should be first transformed to strings to meet the requirement of the serial port, which can only read and transmit characters. The microcomputer only extracts and processes the data frame in the "$GPMRC" format, the data segments of which are separated by commas. The wanted data can be extracted by the number of commas to increase the processing efficiency. The default geographic information read mode is in "latitude/longitude" in the phone APPs; therefore, the information gain from the serial port should be transformed into the "latitude/longitude" mode. The whole flow chart is shown in Figure 5.

4.3 GSM Data Transmission

The communication between the GSM module and microcomputer is conducted via the serial port. The microcomputer implements data transmission by commands in the ASCII character format. The short message is established in the GSM module, the related commands include the "AT" online instruction, which will return "OK" on the condition of a successful connection with the GSM module. The "AT+CPMS=\"SM\" instruction, which is generally stored in the SIM card, designates the storage location of the short message and will return "OK" when the environment is successfully established. The

"AT+CMGF=1" instruction designates the short message in the text mode (generally in English). When "AT+CMGF=0", the phone will receive a Chinese short message. The "AT+CMGS=" instruction designates the owner's phone number and message content. The whole flow chart of the program is shown in Figure 6.

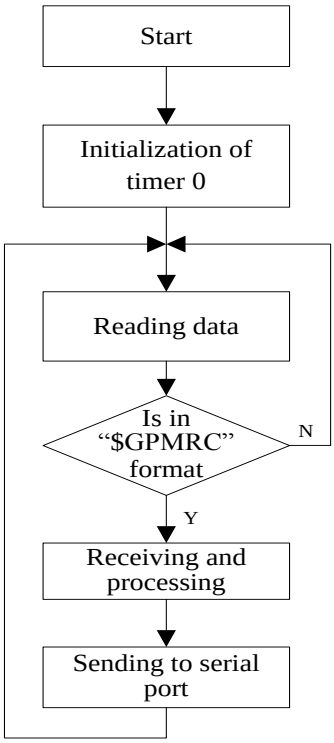

Figure 5. Flow Chart of the Program in the GPS Module

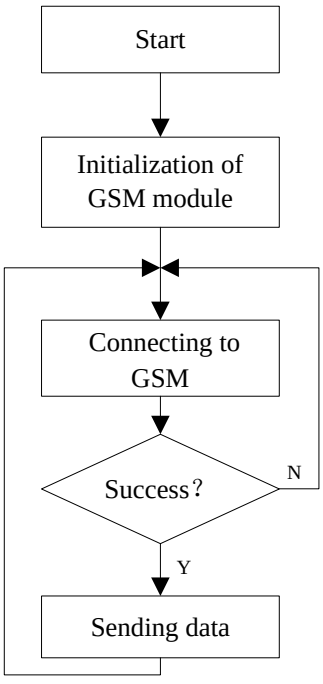

Figure 6. Program Flow Chart of the GSM Module

4.4 Design of the Phone APP

The functions of the phone APP include monitoring, computing, information displaying, comparing, and voice broadcasting. The software construction is shown in Figure 7. The monitoring module is responsible for the detection of new arriving short messages that contain the latitude and longitude information of the vehicle. The input and output of the comparator are connected with the comparing module and the voice-broadcasting device separately. When the difference between the vehicle movement distance and predetermine distance exceeds the designated threshold, the comparator will activate the voice-broadcasting device to play a recorded alarm.

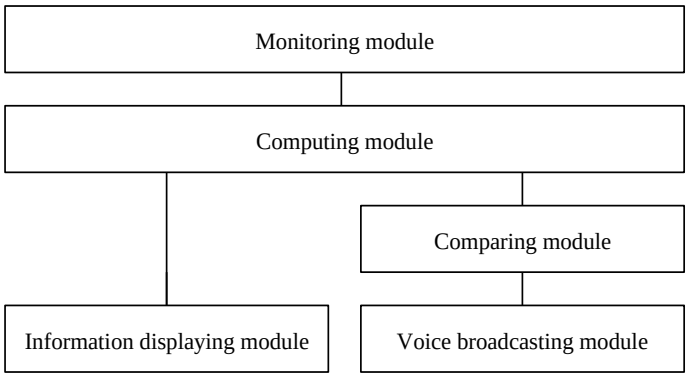

Figure 7. Sketch Map of the Construction of the APP Function

4.4.1 Short Message Processing in Phone APP: The monitoring software in the APP terminal consists of vehicle location displaying, voice alarming, and processing after the detection of the vehicle moving. To obtain the vehicle location short message via the GSM network, the system has a short-message-broadcast monitoring module in the Android client. This module can obtain the new arriving short message and compare the number of the current hardware and the number extracted from the new short message. If the two numbers are the same, the message will be extracted and analyzed (the message on the hardware are standardized in a unified form, generally are longitude and latitude) by intercepting the string, and the current vehicle location will be displayed on the digital map.

4.4.2 APP for Vehicle Location Displaying and Alarming: When the on-vehicle terminal is powered, the original vehicle location will be sent to the phone of its owner and it will be displayed on the digital map by initializing the monitoring phone APP. When the monitoring program detects the difference between the current longitude and latitude and the predefined value is more than 10 s (100 m in equivalent), the on-vehicle terminal will re-send the newest vehicle location data to its owner. When the location is outside of the predefined range, the alarm system will be activated, and the voice-alarm will be broadcasted. The remote vehicle locating and tracking can then be assured. The flow chart of the APP is shown in Figure 8.

5. System Debugging and Implementation

5.1. Debugging of GSM Module

The SIM card is installed into the module and is powered up. The GSM module is connected to the PC, and the electric source is started after checking correctly. Thereafter,

open the serial port-debugging tool in the PC, choose the right port, type "AT" in the sending box, and press "Enter." "OK" in the display frame indicates that the system is online. "AT+CMGF=1" is sent, "OK" in the display frame indicates that the short message is established in text mode. "AT+CMGR=1" is sent, and the content of the short message is displayed. The command "AT+CSQ=?" is used to analyze the message quality and returns a number to denote the signal quality. The command "AT+CNMI=2,1" can create a prompt when a new short message arrives; an "OK" in the display frame indicates that the command is set correctly.

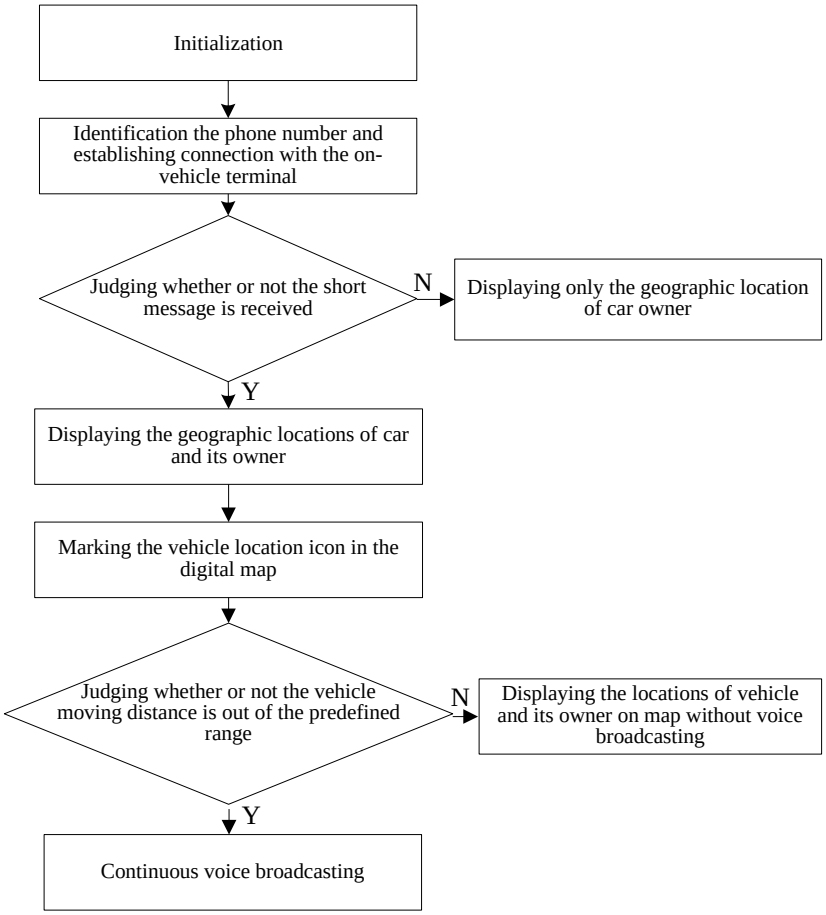

Figure 8. Flow Chart of the Vehicle Location Displaying and Alarming Program

5.2 Debugging of the GPS Module

The GPS module is powered and then connected the data port of the GPS module to the PC emulation serial debugging tool, which help us to view directly the testing results of GPS in "$GPMRC" format.

```
$123RMC,053027.438,A,2815.1608,N,11301.2390,E,0.33,319.7,290412,,*34
$123RMC,053029.441,A,2815.1607,N,11301.2390,E,0.27,319.7,290412,,*3E
$123RMC,053031.438,A,2815.1606,N,11301.2389,E,0.27,319.7,290412,,*30
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$123RMC,053035.000,A,2815.1611,N,11301.2396,E,0.30,319.7,290412,,*35
$123RMC,053037.000,A,2815.1614,N,11301.2401,E,0.00,319.7,290412,,*38
$123RMC,053039.000,A,2815.1618,N,11301.2405,E,0.00,319.7,290412,,*3E
$123RMC,053041.000,A,2815.1621,N,11301.2409,E,0.00,319.7,290412,,*37
$123RMC,053043.000,A,2815.1624,N,11301.2414,E,0.00,319.7,290412,,*3C
$123RMC,053045.000,A,2815.1628,N,11301.2418,E,0.00,319.7,290412,,*3A
$123RMC,053047.000,A,2815.1631,N,11301.2422,E,0.00,319.7,290412,,*39
$123RMC,053049.000,A,2815.1634,N,11301.2426,E,0.00,319.7,290412,,*36
$123RMC,053051.000,A,2815.1637,N,11301.2430,E,0.00,319.7,290412,,*3B
$123RMC,053053.000,A,2815.1640,N,11301.2434,E,0.00,319.7,290412,,*3D
$123RMC,053055.000,A,2815.1643,N,11301.2437,E,0.00,319.7,290412,,*3B
```

Figure 9. Testing Results of GPS in "$GPMRC" Format

5.3 Debugging of Phone APP

Only the car owner's mobile phone can install the monitoring APP successfully. Therefore, during APP debugging, the correct phone number must be set to receive the short messages. The received short message in "longitude/latitude" format is shown in Figure 10.

Figure 10. Short Message of the Vehicle Location Shown in the Owner's Phone

After receiving the short message, the car owner can start the APP program (Figure 11). The current location of the owner himself and the vehicle location will be displayed on the digital map separately. In the example, the owner is in Hangzhou, and the car is in Changsha. When the parked car leaves the original parking location for more than 100 m, the monitoring APP will detect the variation, display the new location, and alarm the owner with the voice message "attention please, your car is moving out of the predefined place!" As shown in Figure 11, the requirement of system design is satisfied on the basis of the approval APP testing.

Figure 11. Results of the Vehicle-Monitoring APP

6. Conclusion

Aiming at the shortcomings of existing vehicle-monitoring systems, such as the requirement of a powerful background database, user charging, and registering, a new GPS/GSM-based on-vehicle monitoring and tracking system is presented. This system employs the STC89C52 core. The change in the longitude and latitude of the vehicle during its movement can be obtained by the GPS module when the variation is more than 0.1 cm (about 100 m). When the location of the vehicle changes, the GSM module will send a location variation short message will be sent to the car owner. The message will show the current vehicle location on the digital map, and a voice notification will keep on broadcasting to remind the car owner of the location changes. The hardware of the new system only needs an on-vehicle terminal and smart phone terminal. Therefore, the proposed system has low cost, requires low facility maintenance, and fits the needs of the general vehicle owner.

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