A VEHICLE TRACKING SYSTEM BASED ON GPS

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ABSTRACT

Vehicle tracking system based on GPS has been paid more and more attention. The system consists of GIS(Geological Information System) , master station, movable station and communication network. Movable stations installed on automobiles transmit their position and status messages to the master station. All vehicles' tracks are drawn on the electrical map displayed by the master station's computer screen in real time. Vehicles' alarming signals can also be transmitted to the master station simultaneously.

This paper presents a whole designing scheme of the vehicle tracking system, then it makes a thorough introduction to the system's performance and working procedure. The key technologies employed by the system and the relations between them are also discussed in details in the paper.

KEYWORDS

GPS, GIS, Modem, data link, vehicle tracking

INTRODUCTION

The vehicle tracking system based on GPS is designed to surveillance all the moving automobiles on the master station's computer screen and make sure all the vehicles running safely.

The system is based on GPS, GIS (Geological Information System) and radio data link.

- Since the whole GPS constellation was built up in June 26th 1993, GPS technologies have been developing very quickly. Some companies such as Trimble, Motorola, Rockwell and Garmin have developed many new types of GPS receiver with low price, small volume and high accuracy, this push forward developments and applications of the civil GPS technology greatly. The GPS receiver which is used in the system can be chosen from different companies.

- GIS has also been widely used in city planning, resources exploration, traffic management and geological analysis. The tools and methods used in GIS field can be transplanted to develop the electrical map conveniently.

- Radio data link takes use of mobile digital communication technologies. In this areas, a great many radio products with high performance can be gotten.

So, all the system's technical requirements have been satisfied. There is a great potential demand for the system in the society. Under this circumstance, vehicle tracking system which employs the GPS, GIS and radio digital communication is integrated.

SYSTEM'S ARCHITECTURE

The vehicle tracking system consists of one master station and many movable stations. The movable station is composed of a GPS receiver, a microcomputer, a Modem and a transceiver. A SUN work station displaying the electrical map is one of the master station's main equipment, other parts which consists the master station are reference GPS receiver, Modem, transceiver and computer etc. The following figure indicates the system's architecture.

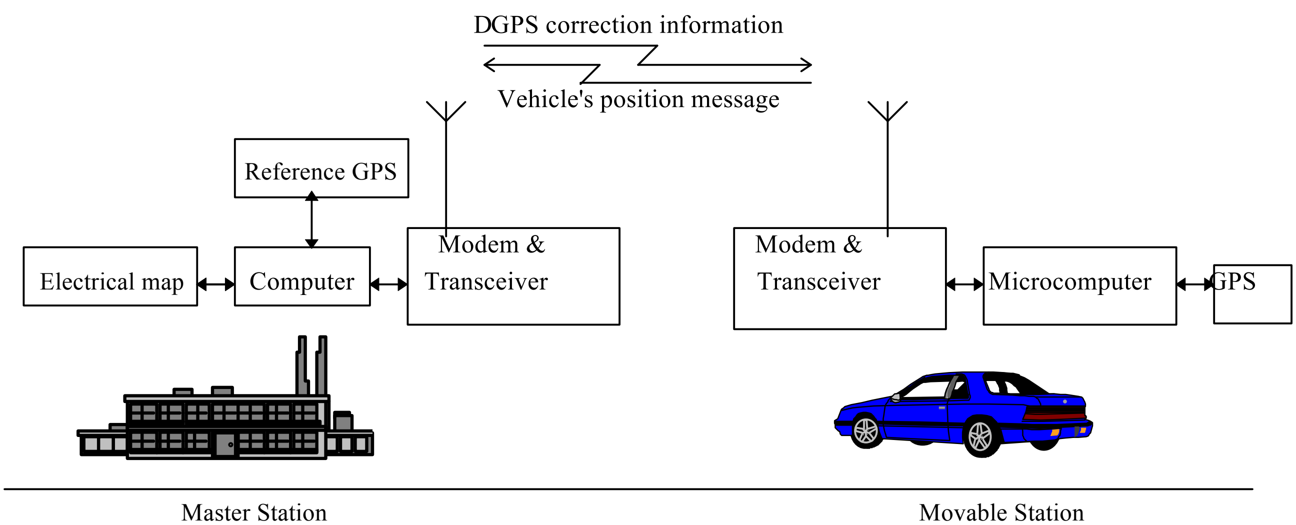


Figure 1 The System's Architecture

The system's working procedures are as follows:

1. In normal working period of the movable station, the microcomputer reads data from GPS receiver, then extracts useful information such as position, velocity and time from the data stream.
2. When it's time for the movable station to send its position message, its microcomputer sends the automobile's position and status information to the

Modem. Then the FSK signals output by the Modem are transmitted to the master station by the transceiver at the same time.

3. When the master station receives the movable station's signals, its transceiver demodulates it firstly, then the Modem does it for the second time. The master station's computer reads the movable station's information and transfers it to the SUN work station. Then the moving track of the vehicle is drawn on the electrical map.

4. The master station's computer reads differential GPS correction information from its reference GPS receiver and broadcasts to all the movable station through the transceiver.

5. The DGPS correction message received from the master station is sent to the movable station's GPS receiver by the microcomputer. The GPS receiver can do the DGPS correcting calculation by itself.

6. The movable station provides four buttons for users. Under emergency or other unexpected situation, corresponding button is pushed down, then the alarming signals are transmitted out without any hesitation.

SYSTEM'S REALIZATION

1. GPS Receiver:

Motorola's 6-channel GPS receiver modules are adopted. Each channel of this versatile receiver independently tracks both code and carrier phases for superior performances required in today's GPS user environment. Time recovery and differential GPS features also are inherent. Combined with its new, low-profile, active antenna, it affords the engineer new freedom in many applications. 3-D position within 25 meters(without SA) or 10 meters (In DGPS) can be provided. It contains a RS232C port and can be connected to the computer's serial port directly.

2. Data Link: Data link involves FSK Modem, UHF radio transceiver and communication protocols. Their connecting relations are shown in Figure 2. FSK Modem is directly controlled by the computer. FM radio transceiver is connected to the Modem, it works in UHF band. Automobile's position and status message with 20 bytes long is sent out once per second in 1200 bps Baud rate.

- Modem: The Modem is developed in terms with practical requirements. It has two connectors, one is RS232 port connecting to the PC's serial port, another is joined with the transceiver. AM7910 is the key component in the Modem. It is a high performance VLSI chip. It can convert the FSK signal to digital signal, or digital signal to FSK signal either. The Baud rate is 1200bps. Using Modem, the capability of anti-inference is improved greatly.

- Radio Transceiver: Adopts Motorola's GM 300 FM radio transceiver. Its RF is 430MHz, belongs to UHF band and its Power is 18W.

- Communication Protocols: Highly efficient data transporting protocols are made according to the practical requirement. Every message sent out by the movable station contains 19 bytes. See Table 1.

- Error Control: In order to decrease bit error rate (BER) of the system's data communication, Forward Error Control (FEC) has been used in this protocols. (2, 1, 9) convolution code is dedicated in this system. The movable station's position message is 19 bytes long, after coding, the length is doubled, 38 bytes. At the receiving section, the large number decoding method is employed, it can correct two random errors in one byte long or one burst error in four bytes long.

Table 1 The movable station's position message

Message Contents	Length	Explanation
1. Data Packet Head	3 bytes	serve as the data packet start point
2. Vehicle's ID	1 bytes	each vehicle's identifying code, 8 bit, range: 0 to 255
3. Time	3 bytes	hour, minute and second occupying one byte individually, hour: 0 to 23, minute: 0 to 59, second: 0 to 59
4. Latitude	4 bytes	latitude of vehicle's position unit: millisecond
5. Longitude	4 bytes	longitude of vehicle's position unit: millisecond
6. Velocity	2 bytes	vehicle's speed unit: centimeter/second
7. Status	1 bytes	vehicle's current status, 8 bit
8. Data Packet Tail	1 bytes	serve as the data packet end point
Sum up	19 bytes	

3. Realization of DGPS

The accuracy of C/A code (Coarse/Access Code) in GPS is 20 to 50 meters. After carrying out the SA policy (Select Availability), the C/A code's accuracy was dropped down. Its horizontal error is up to 100 meters and its vertical error up to 150 meters. The C/A code accuracy can not meet the system's requirement. So DGPS method should be taken to improve the system's accuracy.

DGPS needs a reference GPS station, the position of the reference GPS receiver's antenna has been measured by other way. When the reference GPS receiver has calculated its position according to the GPS satellite's signals, it compares the position to the known accurate position, then it can get a correction to the pseudorange and the pseudorange rate. The reference station broadcasts the correction to the GPS users nearby, the GPS users use it to correct their position. By this method , it can get accurate position. After DGPS correction, the error can be limited in ten meters. This system's master station have two functions, one is the vehicle's controlling center, the other is the GPS reference station for DGPS.

Differential GPS is inherent in the architecture of Motorola's Oncore GPS receiver type B. It can accept either the RTCM SC-104 message type one or the Motorola' binary DGPS protocols. RTCM SC-104 message type one is the recommended standard protocol in DGPS. Because Motorola's Oncore GPS receiver is adopted by both the master station and the movable station, then Motorola's binary DGPS protocols is been chosen. The master station's GPS receiver is set to send out the DGPS correction every 20 seconds, all the movable stations use it to make differential correction. The radio data link is responsible for the data transferring from the master station to the movable stations. The Motorola's binary DGPS correction message is shown as following.

@@CetttippprrdippprrdippprrdippprrdippprrdippprrdiC<CR><LF>

Table 2 The DGPS Correction Message

Character	Content	Length	Range	Accuracy
ttt	reference time	24 bits	0.0 to 6047990.0	0.1 second
i	satellite's ID	8 bits	0 to 32	
ppp	pseudorange correction	24 bits	-10485.76 to +10485.76 meter/second	0.01 meter
rr	pseudorange rate correction	16 bits	-4.096 to +4.096 meter/second	0.001 meter/second
d	issue of data ephermeris	8 bits	0 to 255	

The movable station's GPS receiver uses the above message to do the following correction:

$$PR(t) = PR_m(t) + PR_0 + (dPR_0 / dt)(t - t_0)$$

In the equation, $PR_m(t)$ is the pseudorange measured at t moment, PR_0 is the pseudorange correction at t_0 moment, dPR_0 / dt is the pseudorange rate correction at t_0 moment.

CONTROLLING COMPUTER

The master station's computer and the movable station's computer are the system's core equipment. The system's controlling software are executed by them. The movable station's tasks and working environment are different from that of the master station. There exists many differences in their structures and performances.

The master station's computer is in the laboratory. It have a good working environment. In this system, a ordinary 486 computer compatible with the IBM PC is used in the master station.

The movable station's computer is installed on the automobile, it should be fit for the shaking environment. A practicable scheme of movable station is designed according to the above requirement. The figure 2 shows the movable station's simplified functional block diagram.

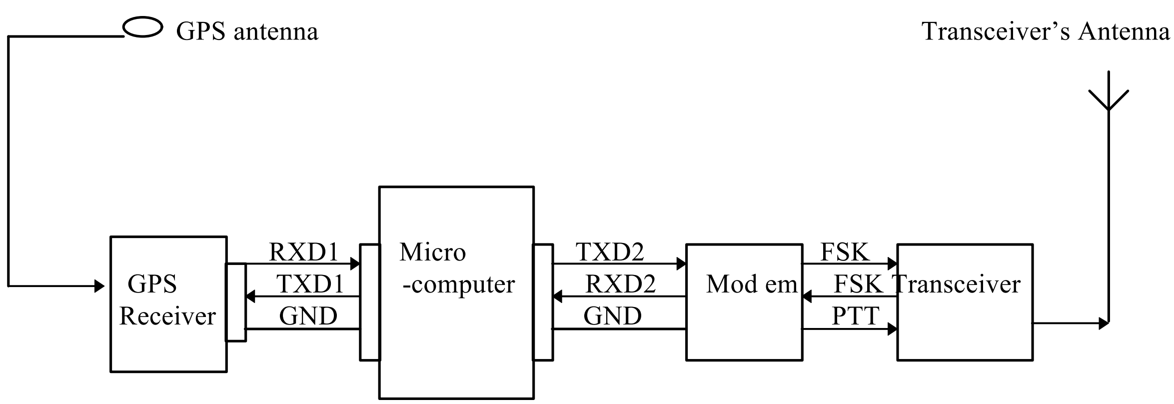


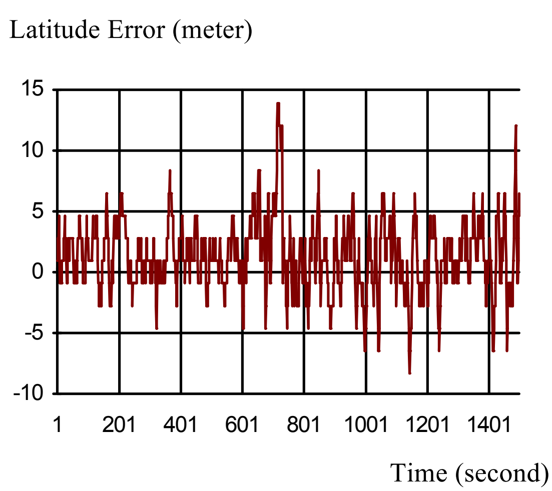
Figure 2 The movable station's architecture

Electrical disk:
Micro 286 PC which measures 24.0cm x 18.5cm x 4.7cm acts as a core equipment to control the GPS receiver and Modem. The keyboard and monitor of the micro 286 PC are omitted. Two RS232C ports are connected to the GPS receiver and MODEM individually. There is a standard AT bus expandable slot inside the computer. A electrical EPROM disk card is designed to be inserted into the slot which acts as a hard disk. DOS3.0 and application program are store in the EPROM. When power is

turned on, DOS3.0 is loaded into memory firstly, then the application executable program is run by DOS3.0 in the memory. So the floppy disk and the hard disk are also omitted too, otherwise, they may be damaged under shaking and bombing circumstance on the automobile . This enhances the system's reliability greatly.

Status producer:
The status producer is composed of four monostable triggers and four buttons on the computer's face panel. The output of the monostable trigger is joined with the computer's interrupt requesting line at the AT bus. When the alarming button is pushed down, the trigger produces an interrupt requesting signal. Having found the signal, CPU gives a quick response to change the automobile's status word and send out the alarming signals. When the alarm is retrieved, normal button is pushed down, then another message is sent out to inform the master station that the movable station is in safety.

The Modem, status producer, and EPROM disk are integrated into one card which is inserted into the AT bus slot inside the computer, GPS receiver is installed at interior of the computer too. So the movable station has a compact size and this makes the system easy to setup and use in the automobile. The reliability of the system are also improved.



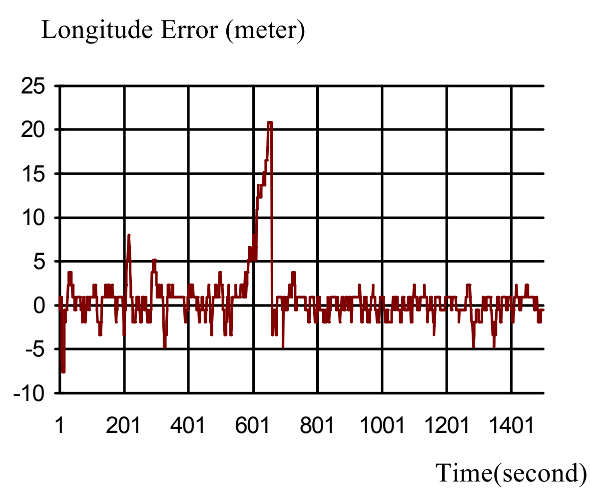


Figure 3 Latitude Error After DGPS   Figure 4 Longitude Error After DGPS

CONCLUSION

The vehicle tracking system are built up according to the above designing scheme. In running course, all the movable stations can transmitted their position messages per second in order, they also can receive the master station's DGPS correction messages per 20 seconds.

DGPS testing result is indicated at the following charts. In the test, one movable station was fixed in a place and worked in DGPS mode, the master station recorded the movable station's position message, the testament lasted about an hour. The latitude and longitude statistics errors are calculated out after the testament. According to the chart, the latitude and longitude errors are within 10 meters at most time, only few points exceeds 10 meters. So it can be concluded that the system's DGPS accuracy can reach to 10 meters .

All the above prove that the designing scheme of the vehicle tracking system based on GPS is correct. Motorola's 6 channel DGPS receiver can provide a positioning service for the system's requirements. Micro 286 PC can succeed in doing the movable station's controlling work; The techniques used in the movable station such as electrical disk, Modem and status producer are all feasible and practical.

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