Research on Real-time Monitoring System of Motion Carrier Based on Satellite Positioning

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Abstract. The system uses CC2541 as the main control chip and mounts PCB antenna to realize Bluetooth wireless communication. GPRS wireless communication adopts SIM900A chip, which provides wireless link for users to upload data to the cloud. The satellite positioning module adopts ZOE-M8Q chip, supporting up to 12 satellite positioning; The cloud SERVER uses Windows Server 2012RC operating system to realize data monitoring and collection. Its based on satellite positioning data can be in the service of Android, IOS, and remote server monitoring system, and serving for the latitude and longitude, speed, time, mileage and other status information recording, storage of the carrier (unmanned vehicle, unmanned aerial vehicles (uavs), etc.). At the same time it can realize the solar energy conservation and emissions reduction, the cloud server storage and data processing through technologies such as GPRS and Bluetooth.

1. Introduction
At present, unmanned vehicles, unmanned aerial vehicles and other high-tech products are emerging and will be produced and used on a large scale in the future. However, the supervision of large-scale unmanned intelligent products is a prominent problem, especially the collection and analysis of big data such as location information. During outdoor voyages such as the desert and sea, when users cannot locate geographic coordinates via cellular networks, satellite positioning data becomes very important. Global Positioning System (GPS) uses a number of satellites orbiting the earth to locate space and time. The satellites in orbit can transmit radio signals at the agreed frequencies in real time. Whether you are on land, in the air or at sea, if you have a portable signal receiver, you can receive a specific signal from the satellite, and determine the position of the moving carrier through analysis. It can be used in military, transportation, surveying and mapping and other fields. But GPS itself does not have the function of digital communication, so it can not meet the growing needs of users. In order to solve the above problems, this paper designs and develops a motion carrier monitoring system based on GPS, GLONASS and Beidou satellite system. At the same time, it uses cloud server and mobile phone to collect Information.

2. System Design

2.1. Algorithm Design

2.1.1. Satellite positioning principle. Each GPS satellite will transmit a set of signals, each of which
includes two different frequency carrier signals L1 and L2, two different ranging codes (C/A code modulated on L1 carrier, P code or Y code modulated simultaneously on L1 and L2 carrier) and satellite orbit information, as shown in Figures 1 and 2.

Figure 1. Spectrum of positioning satellite signal

Figure 2. Modulation of positioning satellite signal

C/A Code, also known as Coarse Code or Capture Code, is mainly used for coarse ranging and pseudo-random code for capturing CGPS satellite signals. It has a code length of 1023 bit, a cycle of 1ms, a digital rate of 1.023 mbt/s and a code width of 293.1m. Its frequency is 1.023 MHz, will only be up on L1 carrier, and will be repeated every 1023 bits, with 1 MHz data as a schedule, convenient for general civilian use.

P Code also known as Precise Code, is mainly used for transmitting pseudo random noise codes with a period of 1.5s, a digital rate of 10.23 mbt/s, and a code width of 29.3m. With a frequency of 10.23 MHz, both L1 and L2 carriers can be used and repeated every seven days. P-codes, which are mainly used for military purposes, are more accurate and less susceptible to interference, and their frequency is about 10 times that of C/A codes.

2.1.2. Point position determination algorithm. The principle is that to ensure the correctness of the position of the point to be measured, the position coordinate of a satellite moving at a high speed at a certain moment is regarded as the known initial coordinate, and the intersection sum method is implemented at the rear position of the space distance, as shown in the figure 3.

Figure 3. Diagram satellite positioning algorithm

Figure 4. Diagram of system design block

To postulate that a time t through the receiver is installed in the ground on the specific location of the signal by the time it takes for Δt receiver, and then according to the poor ephemeris received by the receiver clock other data from the following formula. Type the coordinates x, y, z and vt0 are unknown parameters, including di=cΔti (i=1, 2, 3, 4) respectively for the distance between the four satellites to the receiver. Δti (i=1, 2, 3, 4), respectively four satellite signal reaches the receiver time, c for the
signal propagation velocity is the speed of light. The actual meaning of each parameter: \(x, y\) and \(z\) are the spatial cartesian coordinates of the unknown point to be measured. \(x_i, y_i, z_i (i=1, 2, 3, 4)\) are the spatial rectangular coordinates of the four satellites obtained from the satellite navigation messages at the time \(t\). \(v_t (i=1, 2, 3, 4)\) is the clock difference value of the four satellites provided according to the satellite ephemeris respectively, and \(v_{t0}\) is the clock difference of the receiver. Each receiver contains four unknown data. The four equations above can be used to calculate the spatial coordinates of the unknown points \(X, Y, Z\) and the receiver clock difference \(v_{t0}\). In fact, the receiver is fixed by at least 4 satellites, and according to the spread of satellites, each group of 4 is divided into several groups, and a group of data with small error value is selected as the positioning data through the algorithm, so as to improve the accuracy. The specific relationship is shown in Formula 1, 2, 3 and 4.

\[
\begin{align*}
(x_1-x)^2+(y_1-y)^2+(z_1-z)^2+c*(v_{t1}-v_{t0}) &= d_1^2 \quad (1) \\
(x_2-x)^2+(y_2-y)^2+(z_2-z)^2+c*(v_{t2}-v_{t0}) &= d_2^2 \quad (2) \\
(x_3-x)^2+(y_3-y)^2+(z_3-z)^2+c*(v_{t3}-v_{t0}) &= d_3^2 \quad (3) \\
(x_4-x)^2+(y_4-y)^2+(z_4-z)^2+c^2*(v_{t4}-v_{t0}) &= d_4^2 \quad (4)
\end{align*}
\]

2.2. The Project Design

This paper studies a satellite positioning monitoring system which can record and store the longitude and latitude, altitude, travel speed, time, mileage and other state information of the moving carrier, which can transmit data through wireless communication. The system is mainly composed of positioning module, bluetooth module, GPRS communication module, the solar charging voltage module, GPS module, PC components, such as be able to connect bluetooth with mobile phone APP, realize the data real-time transmission, use GPRS communication technology at the same time to upload the information such as latitude and longitude, speed, acceleration, issued by the text, which can acquisition in real-time and recording time, date, and speed, etc., the cloud server can manage the WEB interface.

2.3. System Hardware Design

Bluetooth CC2541 communication module adopts 3.3V power supply and 32.768K crystal oscillator. It is connected to mobile phone through PCB antenna, with an effective transmission distance of 10 meters, and SMA antenna interface is reserved to increase the effective signal transmission distance. It is convenient to download and debug programs through USB interface.

The satellite positioning module adopts ZOE-M8Q chip, supports GPS and Beidou dual-mode output, and uses the satellite to locate the current position and determine the current time to realize data acquisition. Data transmission relies on the bluetooth module CC2541EMV2.6 with CC2541 as the core. This module has good stability and long transmission distance, and it can transmit the positioning data of the unmanned car to the mobile APP in real time for display. GPRS communication module adopts SIM900A module, which can upload longitude and latitude, altitude, speed, date and time information to cloud server in real time for remote monitoring. Power module adopts 3.7V lithium battery, supplemented by solar stable voltage charging, to achieve the purpose of low carbon and environmental protection. The main battery power supply of the satellite positioning module circuit is 3.3V, and the spare battery power supply is between 1.4V and 3.6V. The external crystal oscillator of J8 and J7 pins is 32.768KHz, the external ceramic antenna of A4 pins is available, and the serial pins of J5 and J4 can be connected with CC2541 for data communication between chips.

3. System Software Design

Data from the GPS module will include information such as longitude and latitude, altitude, time and accuracy to CC2541, it will be after receiving the data processing and compression, via bluetooth protocol transmitted to the user on the phone APP Laptimer, using the Lua language independent writing APP script will receive to extract the data and storage, and provide display interface, data show that the user can read; At the same time, the data is transmitted to SIM900A chip through the serial port. It uses GPRS technology to transmit the data to the cloud server, and the server processes
and stores the data to realize remote monitoring. The specific design block diagram is shown in Figure 5.

3.1 Design of Upper Computer
After the cloud server starts up, it runs Windows Server 2012RC operating system. It uses the pre-configured fixed public network IP address and sets the inbound and outbound rules, such as selecting the server port “3388” for open test. Then it runs the network port monitoring program, sets up the network protocol type as TCP service, monitoring the local computer port “3388” whether to have data to the client request access, if you have access to request record and display the client’s IP address and port number, network and then determine whether the port has received data, if have showed the client data, date, time and other information. This is shown in Figure 6. After running the APP, it will first judge whether the Bluetooth of the phone has been turned on, and then run the WHL HSCRL script program written; The upper computer automatically searches the Bluetooth name, service UUID and feature UUID of the lower computer set by connection, and obtains the compressed packet data sent by the lower computer; At the same time, the corresponding decompression data will be respectively sent to the GPRS, timer, speedometer and acceleration test interface, select different applications, the satellite data will be displayed and stored in different ways. The specific process is shown in Figure 7.

![Figure 5. System general block diagram](image1)

![Figure 6. Flow chart of cloud server](image2)

![Figure 7. Laptimer program flow chart of upper computer](image3)

3.2 Lower Machine Design
After the lower computer is powered, each module is initialized. After CC2541 works, the Bluetooth name, service UUID and feature UUID are set to WHL, FFF9 and FFF6 respectively. Then judge whether to connect to the mobile APP through Bluetooth, and the indicator light 1s flashes once after connecting. The satellite positioning module and the GPRS module judge whether the satellite signal is received successfully and whether it can be connected to the base station network, and display the indicator lights in different states respectively. After successful satellite positioning, RMC data packet and GGA data packet are sent to CC2541, which are processed and compressed and sent to mobile APP through Bluetooth, and then the data collected by the satellite positioning system are uploaded to the cloud server through the serial port control SIM900A module.
3.3 System Debugging and Implementation

The system needs to select effective data for compression and debugging. For example, the format data packets collected by the satellite positioning module include RMC type and GGA type, as shown in Table 1. Among them, UTC time, latitude, latitude direction, longitude, longitude direction, velocity, azimuth, UTC date, number of positioning satellites, HDOP precision and altitude are the data used.

| Table 1 $GNRMC and $GNGGA Data Format |
|----------------------------------------|
| **RMC data format** | **Statements** | **UTC time** | **state (A/V)** | **latitude** | **latitude direction** | **longitude** | **longitude direction** | **Speed (knots)** | **Azimuth Angle (degree)** | **UTC data** | **Magnetic declination** |
|---------------------|----------------|---------------|-----------------|--------------|-----------------------|--------------|------------------------|-----------------|--------------------------|-------------|-------------------------|
| $GNRMC 160145.20$  | A              | $31.16696^\circ$N | E               | 0            | $117.17488^\circ$E   | 0            | $117.15.1475$ E         | $1.019$        | $102.46$                | $190.10$    | $190.10$                |
| $GGA data format$   | **Statements** | **UTC time** | **latitude** | **latitude direction** | **longitude** | **longitude direction** | **GPS state** | **Number of positioning satellites** | **HDOP** | **altitude** | corrected height of the earth ellipse |
|---------------------|----------------|---------------|--------------|-----------------------|--------------|------------------------|----------------|--------------------------|-------------|-----------------|--------------------------------|
| $GNGGA 160145.20$  | N              | $31.16696^\circ$N | E               | 0            | $117.17488^\circ$E   | 0            | $117.15.1475$ E         | 1              | $4.32$                  | $89.2$      | $89.2$                |

Set bluetooth name, feature and service UUID as well as APP script for CC2541, search target bluetooth and connect automatically, as shown in Figure 8.

![Figure 8. The Diagram of Bluetooth Program Settings](image)

The satellite positioning system is acquired, developed and debugged by Alientek STM32F4 to realize the real-time display of longitude and latitude, altitude, speed, positioning satellite data, direction Angle and precision, and convert UNIX timestamp into standard time value, which is convenient for users to watch. Using C/S architecture or B/S architecture, access to real-time satellite data in the debug, called Google, baidu map, such as gold maps API, you can easily get the satellite map, according to the data in the WEB interface can also be shown in APP or server maps satellite monitoring and control system for satellite map shows the coordinates of the monitoring system, including blue cellular network positioning coordinates for the data error is more than 10 m, green for GPS coordinate error is less than 2m. The details are shown in Figure 9.

![Figure 9. Satellite map of monitoring system](image)

![Figure 10. Information diagram of current movement of the system](image)

As shown in Figure 10, Bluetooth name is WHL Btle, time is on April 8, 2019, 9:59min59sec, latitude:31.16696°N, longitude:117.17488°E, 3D GPS positioning, current speed is 0km/h, altitude:57m, HDOP accuracy is 3.0m, refresh rate is 11Hz, orientation and slope Angle can be displayed in real time when the object is moving.
4. Conclusion
This system mainly using satellite positioning technology, transmitting data over a bluetooth connection to the terminal APP, by GPRS module and complete data communication between the cloud server, thus realize the movement of cars, ships, such as unmanned aerial vehicle (uav) carrier information comprehensive monitoring, real-time display and storage geographic coordinates, speed, height, the information such as date/time, has small volume, price is excellent, efficient, safe, environmental protection, energy saving and other characteristics, widely used.

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