GPS Navigation Information Processing and Display Based on VC++

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Abstract

As Global Positioning System(GPS) could provide some navigation information for users such as time, latitude, longitude, and altitude, etc, it has been widely used in various fields like military, communication, measurement and so on. Therefore, it is of great application importance to study the processing method and display way of GPS navigation information. In this paper, on the basis of the positioning principle of GPS, the GPS navigation information processing method is proposed which has combined the PC and the receiver serial communication. The focus of this program is to study the software to process and display the GPS navigation information using the visual programming of VC++. The GPS receiver serial port is used to send real-time navigation information to the PC in this program, and then the time, latitude, longitude, altitude and satellite status and some other information can be displayed in the window frame created by MFC after the extraction of MsComm controls serial port programming. Meanwhile, the received time information can be used to make the simple calendar; the electronic map is loaded with the electronic map control MapX, and then electronic map location function can be achieved using the location information. This design can process and display various GPS navigation information conveniently after the actual test, which can be used in a variety of occasions.

Keywords: *GPS, Navigation information, Serial port communication, VC++*

1. Introduction

Global Positioning System (GPS) is the satellite navigation and positioning system developed by U.S. Department of Defense, which is widely used in the field of navigation, communication, and mapping [1-6]. As a GPS navigation system terminal, the performance of the receiver has higher requirements with the development of a variety of new applications. To adapt to a variety of specific research and development of complex algorithms, GPS receiver has gone through the implementation process from hardware to software. Software receiver is primarily based on the idea of software radio, using hardware as the basic platform for wireless communication to achieve the wireless and personal communication function by software as much as possible [7]. GPS software receiver, compared with traditional hardware

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receiver, has the advantage of flexibility, openness, and ease, which has become a research focus in recent years.

To achieve the GPS software receiver and contribute to the basic theories and methods of GPS navigation information processing and display, this paper proposes the program combined the PC and receiver serial communication which focuses on the software to process and display the GPS navigation information using the visual programming of VC++, and then presents the processed navigation information to users in an appropriate way.

2. Basic Principles of GPS Positioning

With the instant position of high-speed satellite as the known initial data, the basic principle of GPS positioning is to adopt the spatial distance intersection method to determine the position of the points to be measured. Assume that the GPS receiver is placed on a target point on the ground, the time Δt that the GPS signal reaches the receiver can be determined, coupled with the on the satellite ephemeris received by the receiver and other data, the following four equations can be identified[8]

$$\sqrt{(x_1 - x)^2 + (y_1 - y)^2 + (z_1 - z)^2} + c(t_u - dt) = r_1 \quad (1)$$

$$\sqrt{(x_2 - x)^2 + (y_2 - y)^2 + (z_2 - z)^2} + c(t_u - dt) = r_2 \quad (2)$$

$$\sqrt{(x_3 - x)^2 + (y_3 - y)^2 + (z_3 - z)^2} + c(t_u - dt) = r_3 \quad (3)$$

$$\sqrt{(x_4 - x)^2 + (y_4 - y)^2 + (z_4 - z)^2} + c(t_u - dt) = r_4 \quad (4)$$

x, y and z in the above four equations refer to the rectangular coordinate in the receiver space, t_u is the clock correction of the receiver, which are all unknown quantities; $\rho_i=c$ $(i=1,2,3,4)$ respectively represents the distance between the satellite i and the receiver, where Δt_i means the time that the satellite i reaches the receiver, x_i, y_i and z_i are the rectangular coordinate in the satellite i space at the moment t, δt is the clock offset of satellite, and c is the speed of light (they are all known quantities). These four equations can be used to calculate the coordinates x, y, z and the clock correction t_u of the receiver.

3. GPS Navigation Information Processing and Display Program

In this program, PC is used to process and display the GPS navigation information, so first the corresponding interface should be used to achieve the communication between the GPS receiver and PC. GPS receiver is responsible for receiving navigation information, and serial communication modules receive data regularly to send it to the PC. PC data processing module is responsible for processing the data which can meet the requirements, thereby generating various desired navigation information and displaying the related information. The information processing flow is as shown in Figure 1.

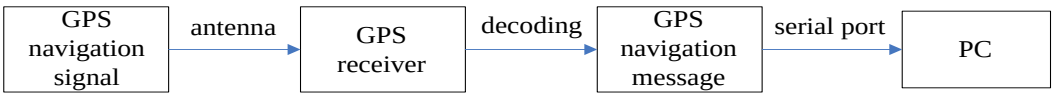

Figure 1. The Process of GPS Navigation Information Processing

In the process of GPS navigation information processing and display, it is necessary to judge and analyze the GPS frame information, obtain the required frame information, and then conduct the related analysis in turn. Meanwhile, the appropriate application window is established to display the basic information of GPS navigation and satellite status information. The acquired time information, latitude and longitude information can also be used to respectively achieve the positioning of electronic calendars and electronic maps. The specific scheme of navigation information processing and display is as shown in Figure 2.

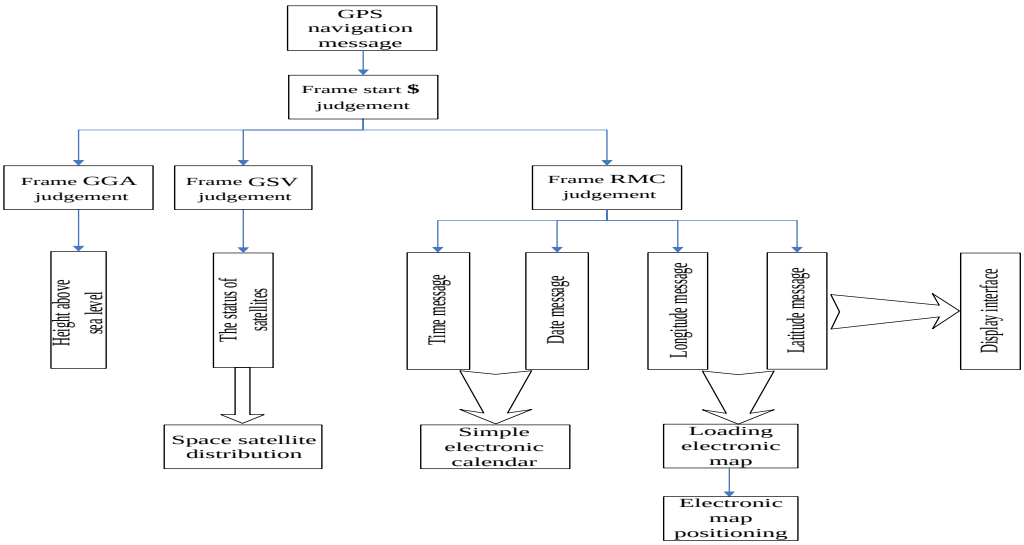

Figure 2. GPS Navigation Information Processing and Display Program

4. GPS Navigation Information Processing and Key Technologies of Display

4.1. Output Format of GPS Receiver Data

When the GPS receiver obtains latitude, longitude, altitude, speed and time information of users' geographic location through GPS positioning solution method, it is equipped with a serial port (TTL or RS-232 level) to distribute information in a special data format in order to transmit the calculated navigation information to the peripherals. GPS is characterized by much communication protocol, but the most widely used is NMEA0183 protocol [9]. It provides for the data format as follows: the beginning character of each frame is "$", followed by the type of information and the positional parameters, which are separated by commas. Data transfer rate is 4800bit/s, with 8-bit data bit and 1-bit stop bit. There is no parity bit. Besides, it formulates more than 10 kinds of GPS statements like GPRMC, GPGSA, and GPGSV, *etc*.

GPS receiver will return data in a certain format at regular intervals after it is powered on. A frame of complete data format is shown in the following:

$GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>*hh

$GPGGA,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,M,<10>,M,<11>,<12>*xx<CR><LF>

In the statement, the GPRMC type is recommended to be used as it is the GPS data format with the minimum amount of data. GPGGA type is the information type of the output statement of the GPS fixed data, with GPS location information included, which contains the altitude parameters. For other types of information, please refer to literature [9].

4.2. Serial Communication and Monitor Thread of MSComm

Microsoft Communications Control (hereinafter referred to as MSComm)[10] is serial communication programming ActiveX control under simplified Windows developed by Microsoft Corporation, which provides applications an easy way to send and receive data via the serial interface. The use process of the control included the initialization, baud rate settings and buffer settings, communication mode settings, and response processing of events. The essence of the communication process of MSComm control is to complete a query, settings and communication on the serial port through operating the properties of the MSComm control and responding to OnComm events.

Serial monitoring thread monitors serials in real-time at the background. When the serial receive data, it immediately calls the reading thread to automatically receive data and at the same time send the receipt information to the main thread [11]. Serial monitoring thread will continue to supervise the serial after sending this message. In this way, it balances processing messages and monitoring serials, ensuring the data received in real-time while also saving resources. The process is shown in Figure 3.

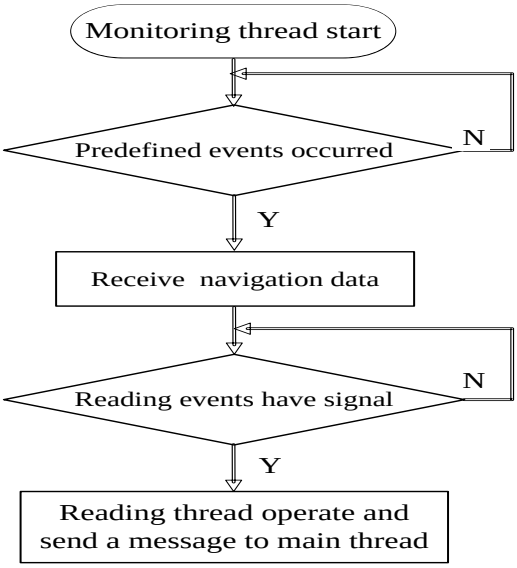

Figure 3. Serial Monitor Thread Process

4.3. MFC Applications

The essence of MFC is a class library [12] that contains many objects defined by Microsoft. Using MFC application in VC++ environment, we can create a standard Windows application program interface, and then re-program the interface design, including menu design, the design of the toolbar, status bar, and dialog design. The display application of

navigation information in this paper is based on MFC dialog. The flow of the main control program of the software is shown in Figure 4, which mainly realizes the processing and display function of various navigation information.

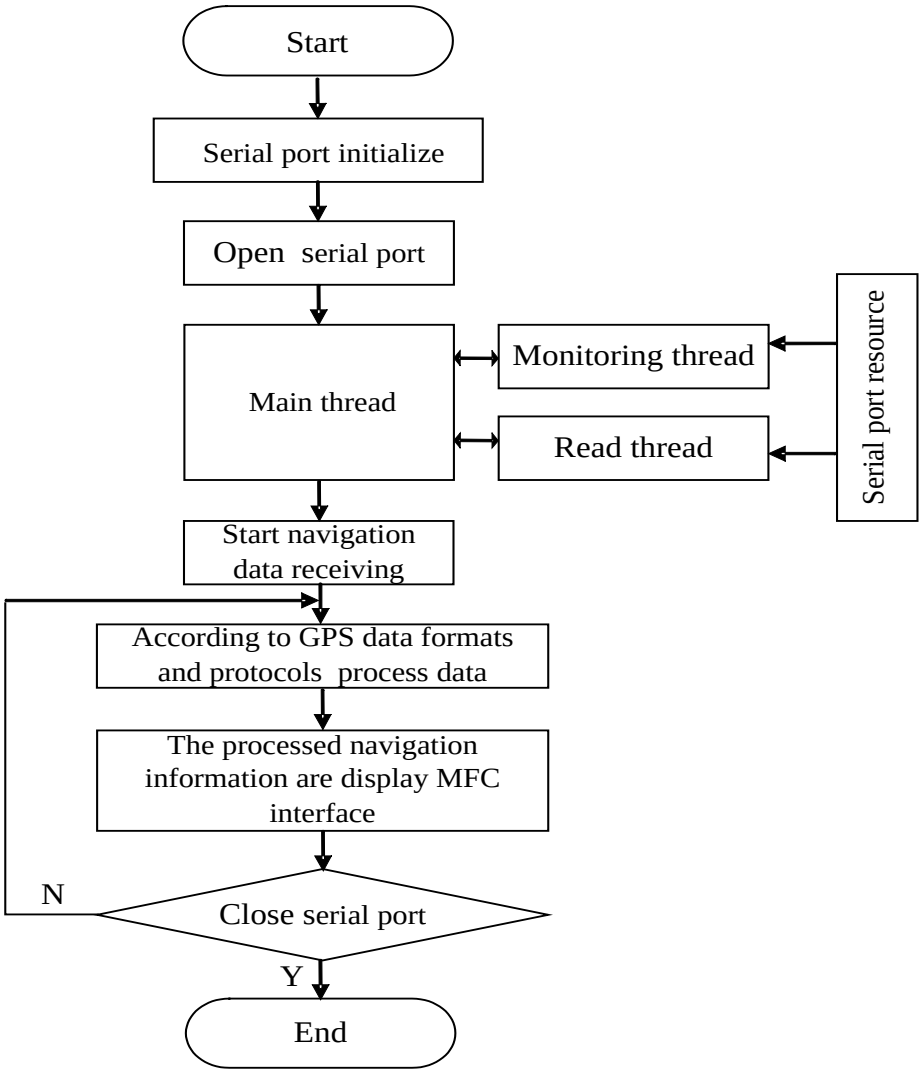

Figure 4. Flow of MFC Main Control Program

4.4. MapX

MapX is a programmable control based on ActiveX technology, which uses the map data format consistent with MapInfo Professional and achieves most functions of MapInfo Professional. Key features of MapX include displaying MapInfo format map, zoom in and out, reducing the size, roaming, and selecting operation of map. In visual development environment, just place the MapX control into the window, set the property or call a method or corresponding events in the design stage, VC can achieve the visualization, thematic analysis, geographic queries, geocoding and other rich functions of map information system[13].

5. Realization of GPS Navigation Information Processing and Display Based on VC++

5.1. The Acquisition and Display of Basic Information

The basic information mainly includes the time, date, longitude, latitude, and altitude and satellite state. Add MSComm serial port controls in VC and use the serial port to receive GPS navigation information. As the received information does not belong to the common-type CString, the VARIANT is used to save the data in the serial buffer data and then after it is converted to a CString type, it should be processed according to the NMEA0183 protocol of GPS, followed by the acquisition of all kinds of information.

The display of basic information is to establish a MFC dialog box procedure in VC and add the required dialog resource, controls and image resources. The display program of navigation information adopts the main dialog box (IDD_GPSRECEIVE_DIALOG,), the basic information dialog (IDD_DLGBASICINFO), the satellite status dialog box (IDD_DLGPOSTION), the electronic map dialog (IDD_DLGMAP) and the calendar dialog box (IDD_DLGCALD). Meanwhile, the required ActiveX control (IDC_MSCOMM), etc are also added. The receiver receives the information and then conduct analysis and judgment, which will be displayed in the control.

As the time and latitude and longitude information is included in the RMC information field, while the altitude information is contained in the GGA information field, so the implementation process is to carry out traversal for the information with the head of "$ GPGGA", which means that the implementation process is to carry out traversal for the information with the head of “$GPRMC” and “$GPGGA”, and conduct information extraction with the “,”as the split point. The code of the major implementation algorithm is shown as follows

```
start=m_sRecData.Find("$GPRMC");// Time, latitude and longitude information extraction
    end=m_sRecData.Find('$',start+1);
        if (end>start)
        {
                sRMCInfo=m_sRecData.Mid(start,end-start);
                int index=0;
                start=end=0;
                while(index<10)
                {
                        ++index;
                        end=sRMCInfo.Find(',',start);
                        switch(index)
                        {
                        case 2:
                                g_sUTCTime=sRMCInfo.Mid(start,end-start);
                                break;
                        case 3:
                                break;
                        case 4:
                                g_strLongitude=sRMCInfo.Mid(start,end-start);
                                break;
```

```
                    case 5:
                            g_strLongitude+=sRMCInfo.Mid(start,end-start);
                            break;
                    case 6:
                            g_strLatitude=sRMCInfo.Mid(start,end-start);
                            break;
                    case 7:
                            g_strLatitude+=sRMCInfo.Mid(start,end-start);
                            break;
                    case 10:
                            g_sUTCDate=sRMCInfo.Mid(start,end-start);
                            break;
                    default:
                            break;
                    }
                    start=end+1;
            }
```

g_sUTCTime is the UTC time information, g_sUTCDate is UTC date information, g_strLongitude is longitude information, g_strLatitude is latitude information.

```
start=m_sRecData.Find("$GPGGA");//Altitude information extraction
  end=m_sRecData.Find('$',start+1);
    if (end>start)
    {
            sGGAInfo=m_sRecData.Mid(start,end-start);
            int index=0;
            start=end=0;
            while(index<12)
            {
                    ++index;
                    end=sGGAInfo.Find(',',start);
                    switch(index)
                    {
                    case 10:
                            g_sElevation=sGGAInfo.Mid(start,end-start);
                            break;
                    case 11:
                            g_sElevation+=sGGAInfo.Mid(start,end-start);
                    default:
                            break;
                    }
                    start=end+1;
            }
    }
```

The acquired basic information could be displayed in the basic information dialog box (IDD_DLGBASICINFO). In this process, the time and date information should be analyzed again and then converted to Beijing time.

Figure 5 presents the current UTC time, date, and the Beijing Time, coupled with the local latitude, longitude, and altitude information.

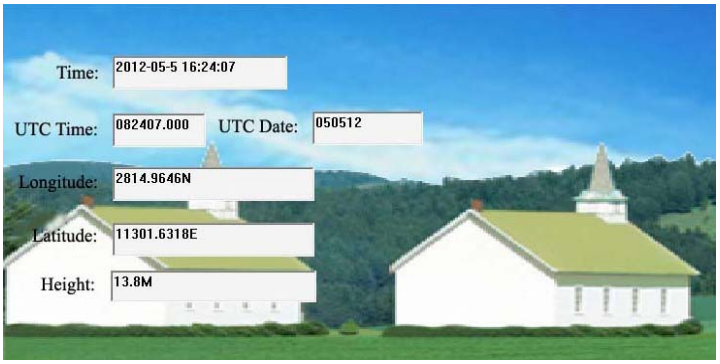

Figure 5. Display of Basic Information

The query of the network indicates that the local longitude is 28.248577346671677 and the latitude is 113.02659273147583. There is a certain deviation between them and the deviation of time information and network time is relatively small, which is due to the accuracy of the GPS receiver itself.

5.2. Electronic Mapping and Positioning

The MapX control is dynamically generated in the electronic map diolog (IDD_DLGMAP) and the electronic map file“Maps/ccsu.gst”is called. This paper adopts the three-dimensional map in Google Maps and loads the menu in the electronic map to facilitate the control and search the map, thereby achieving zooming in, zooming out, movement and other functions. As the information file of loaded electronic map contains the latitude and longitude information of the current position, match it with the current latitude and longitude information received by the receiver, therefore the electronic map positioning can be realized. In this electronic map positioning, a picture shows the current location information. When the receiver completes the receiving process, create a new layer in the current map location and load BMP image in this layer, which can display the current location and achieve the function of positioning. The position of the loading image is the current location, as shown in Figure 6.

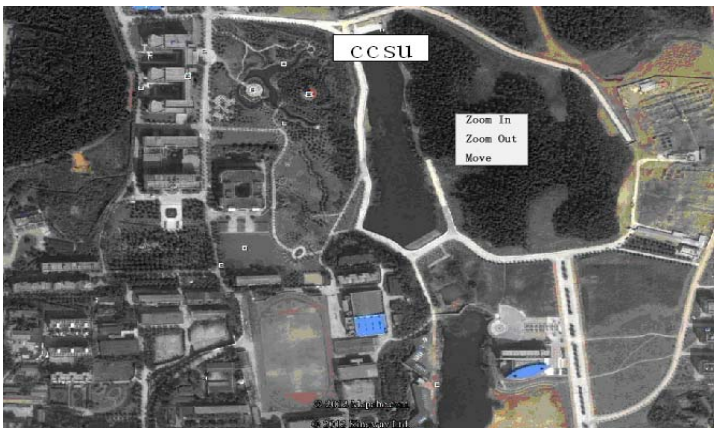

Figure 6. Electronic Map Display and Positioning

5.3. Drawing Satellite State

First obtain the number of satellites to extract all the satellite information, and save the satellite information is in pStatelite, including satellite number, satellite elevation angle and satellite spin angle. To draw the satellite information can be achieved by drawing information in the Static control, so it is necessary to create the class, inherit CStatic and rewrite the OnPaint () method. Draw the circles and lines in OnPaint () to determine its location according to the elevation and rotation angle, simulate and display the layout of the analog space satellites. Based on the acquired satellite status information, its location can be identified by number by the distribution of concentric circles, and represent the angle in an outside-in order. The circumference of the arc represents the rotary angle, as shown in Figure 7.The code of the major implementation algorithm is shown as follows

```
for (int i=0;i<7;i++)
    {
    pDC>Ellipse(sateShowCenter.xi*CIRCLEINTERVAL,sateShowCenter.y-
i*CIRCLEINTERVAL,sateShowCenter.x+i*CIRCLEINTERVAL,sateShowCenter.y+i
*CIRCLEINTERVAL);
    }
    pDC->SelectObject(gray_pen);
    pDC->MoveTo(sateShowCenter.x,sateShowCenter.y-7*CIRCLEINTERVAL);
    pDC->LineTo(sateShowCenter.x,sateShowCenter.y+7*CIRCLEINTERVAL);
    pDC->MoveTo(sateShowCenter.x-7*CIRCLEINTERVAL,sateShowCenter.y);
    pDC->LineTo(sateShowCenter.x+7*CIRCLEINTERVAL,sateShowCenter.y);
    CPen dot_pen(PS_DOT,1,RGB(128,128,128));
    pDC->SelectObject(dot_pen);
    pDC->MoveTo(sateShowCenter.x-
5*CIRCLEINTERVAL,sateShowCenter.y+5*CIRCLEINTERVAL);
    pDC->LineTo(sateShowCenter.x+5*CIRCLEINTERVAL,sateShowCenter.y-
5*CIRCLEINTERVAL);
    pDC->MoveTo(sateShowCenter.x-5*CIRCLEINTERVAL,sateShowCenter.y-
5*CIRCLEINTERVAL);
    pDC-
>LineTo(sateShowCenter.x+5*CIRCLEINTERVAL,sateShowCenter.y+5*CIRCLEIN
TERVAL);
```

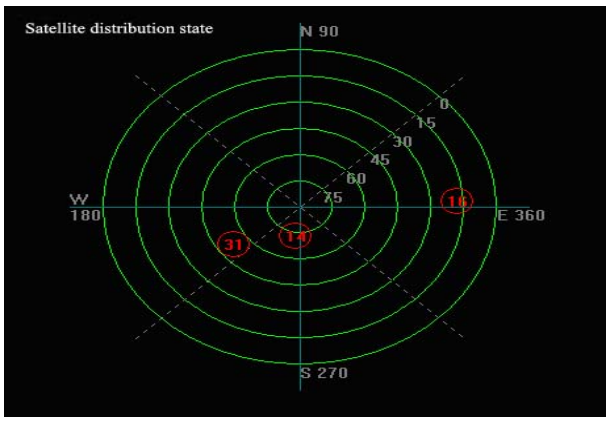

Figure 7. Satellite Distribution Map

In Figure 7, the position of the satellite is marked by the red circle and serial number. The concentric radius represents the angle of elevation of the satellite, while the entire circumference refers to the swing angle of the satellite. Therefore, the current location of No. 14, 16, 31 satellite can be learned from the figure, meanwhile, the status information of different satellites at different time can also be acquired.

5.4. Realization of Simple Calendar

Call the class ColeDateTime based on the currently acquired date and time information, and A ColeDateTime value represents an absolute date and time value. According to the current date and time, instantiate the class and obtain the number of the current weeks through the class function. Create a new dialog resource, load the background image in the dialog box, and input the current date and week. When the mouse hovers over the time controls, the dialog box is displayed. Move the dialog box to the upper-right corner of the computer screen and add an event to hide the dialog box through double clicking. In the process of achieving the calendar, it can also enhance visual effects through loading the background picture and changing the font size and color, as shown in Figure 8.

Figure 8. Simple Calendar

6. Conclusions

In this paper, starting from the processing and display of GPS navigation information using software, the MSComm is used to achieve the serial communication between GPS receiver and PC, thereby realizing the processing and display method of GPS navigation information under the environment of VC++. In this method, the MSComm control could be used to regularly receive and process the navigation information sent by GPS receiver serial, and then display some basic information such as time, latitude, longitude, altitude and satellite state, etc, coupled with the electronic map positioning and electronic calendars. The software used to process and display GPS navigation information has a good application value due to its advantages like a friendly interface, simple and intuitive, easy to operate, and low cost, *etc*. Moreover, the Bluetooth, infrared interface and other interfaces can also be used to achieve the connectivity between GPS receiver and PC, which endows it better flexibility.

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