

Mobile Guardian: A Novel Positioning and Monitoring System for Outdoor Special Users Based on GPS

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Abstract

Different to traditional vehicle positioning and navigation systems, requirements of positioning operations for individuals are always contingently, and it pays more attention to making navigation devices portable and easy to use. Based on GPS and GSM, a novel positioning and monitoring system for outdoor special users called Mobile Guardian is presented in this paper. Through analyzing the structure of GPS data, location-related information such as longitude and latitude of users can be extracted from GPS data stream. The GSM module which supported AT commands is used to transmit these location data and telecommands between users and the monitoring center. And the technology for encapsulating and parsing XML spacial data is utilized for Google Earth to display the detailed geographical information on the screen. Experiments show that the system is effective and could be popularized to family monitoring.

1. Introduction

Currently the scale of city is expanding continuously. It is very important for a modernized city characterized by digital management to set up an efficient and uniform city GPS. At present, research in this field is mainly concentrated on the positioning and navigation of large-scale devices such as vehicles and ships [1][2]. However, there hardly exists GPS positioning system for individual especially some outdoor special users including dementia patients and young persons, which has become an urgently problem to be solved for city management departments [3]. Since selective availability was discontinued on 1 May 2000, location accuracy has been increased greatly. This accuracy is appealing to researchers, since it makes it possible to implement a GPS system for individual.

Different to traditional vehicle positioning and navigation systems, requirements of positioning operations for individuals are always contingently, and it pays more attention to providing more portable and cheaper navigation devices [4]. Based on great efficiency of GPS, high-transmission performance of GSM and visual advantage of GIS, this paper researches and develops a wrist-type GPS positioning system for outdoor special users called Mobile Guardian.

This paper is organized as follows. In Section 2, an overall architecture of Mobile Guardian is presented. In Section 3, some key technologies and issues in the design and implementation of the system are described in detail. In Section 4, some experiments are shown and discussed. In Section 5, the conclusion is given

2. System architecture and components of Mobile Guardian

The whole city GPS system is composed of several subsystems with different functions. Mobile Guardian is one of the most important subsystems, and its objective is to implement the positioning and navigating for individuals in cities especially some special users. The schematic architecture of Mobile Guardian is outlined in Figure 1. The following sections provide details for each of the main components.

2.1. Structure of embedded GPS receiver

Outdoor special users who need the positioning or nursing service would take the portable embedded GPS receiver along with them. And the positioning and analysis of geographical location are realized by GPS receivers according to the signals received from satellites. The principle diagram of the embedded GPS receiver is depicted in Figure 2 [5]. One key factor for this design is that some additional accessories are

excluded due to the significant price and power consumption. The demo product of wrist-type GPS receiver is shown in Figure 3.

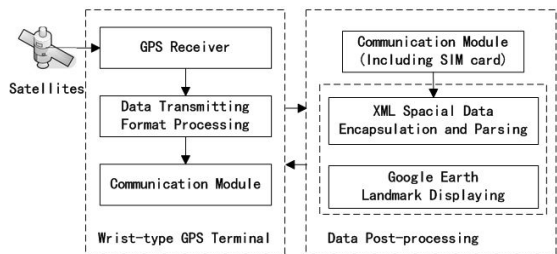


Fig.1. the whole architecture of Mobile Guardian

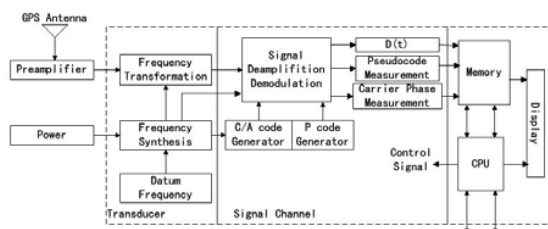


Fig.2. Principal diagram of the GPS receiver



Fig.3. Hardware module of the GPS receiver

2.2. GPS data format and transferring

The NMEA0183 protocol is established as GPS interface protocol standard by National Marine Electronics Association. It defines some sentences and each sentence is essentially an ASCII string representing different meanings [6]. Looking at the available NMEA 0183 sentences, it seems that the \$GPRMC sentence contains all the information we need. If the communications between GPS receivers and satellites are normal, the format of received data is like the following stream: \$GPRMC, <1>, <2>, <3>, <4>, <5>, <6>, <7>, <8>, <9>, <10>, <11>, <12> *hh <CR> <LF>. The actual meaning of each unit is listed in Table 1.

To improve the performance of mobile tracking and monitoring, operations in GPS receivers should be reduced to the greatest extent. Thereby, once the RMC positioning information has been received correctly, it

will be transmitted directly through Short Message Service (SMS) via GSM network and handed over to data post-processing module. The highest transmission velocity of GSM can reach 9.6Kbps, so good performance of transmitting location messages can be ensured.

Table 1 RMC data format

TAG	Name	Description
\$GPRMC	Message ID	Protocol Header
<1>	UTC position	hhmmss.sss
<2>	Status	A=data valid V=data not valid
<3>	Latitude	ddmm.mm
<4>	N/S Indicator	N=northern S=southern
<5>	Longitude	ddmm.mmmm
<6>	E/W Indicator	E=east or W=west
<7>	Speed Over Ground	000.0~999.9
<8>	Course Over Ground	000.0~359.9
<9>	Date	ddmmyy
<10>	Magnetic Variation	in degrees
<11>	Direction of Magnetic Variation	E=east or W=west
<12>	Differential Mode	A = automatic D = differential exclusively
	*hh	Checksum
	<CR><LF>	End of message

2.3. Data post-processing module

The flowchart of GPS data post-processing module is presented in Figure 4.

Once the short messages containing GPS data have been received correctly, data post-processing module would first parse them and extract valuable information, then save it to the database. And the technologies of encapsulating and parsing for XML-based data are utilized to generate KML files, which Google Earth would accept to convert longitude and latitude of users into exact positions in the electronic map. Meanwhile, users can modify the existing landmark data and route information through the interface of Google Earth; the modified results will be saved in the database via KML files for previous route tracking.

In addition, users can set sending intervals of SMS through parameter setting interface, and the communication module will transfer the instructions to GPS receivers.

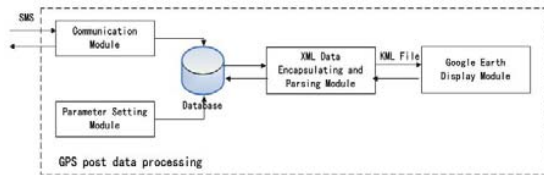


Fig.4. the flowchart of GPS data post-processing

3. Some key issues in the implementation of Mobile Guardian

3.1. Parsing and extracting GIS Information

It is one important task for data post-processing module to analyze and extract GIS information from the received RMC geospatial data [7]. Such data are composed of short sentences and every short sentence includes three parts: frame header, frame trailer, and intra frame. The frame header characterized by ASCII code "\$" determines the structure of the data frame. And data segments containing GIS information are divided by commas in frames. The extracted information includes: latitude, longitude, moving speed, directions and so on. The algorithm of parsing and extracting GIS information is depicted in Figure 5.

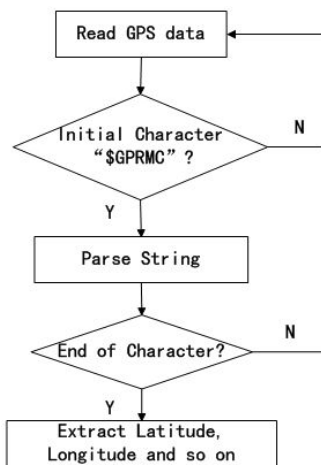


Fig.5. GPS signal processing

3.2. Visual display based on Google Earth

Location-related information extracted should be converted to relevant landmarks to visually display in the electronic map. Google Earth supports two kinds of landmark file: KML and KMZ. KMZ is the default output format, which is a KML file compressed by ZIP and can contain graphs itself. KML is a kind of text file based on XML, which can be edited directly or generated automatically by programs [8]. The working principle of KML file in Google Earth is similar to that HTML files in Web browser. Namely, KML file generated according to KML standards is interpreted and visually displayed in the browser of Google Earth.

KML files are adopted in the implementation of Mobile Guardian. And the semantic format of KML files is defined in Figure 6.

<Placemark>	//Descriptions of landmark information
<name>	</name>
<visibility>	</visibility>
<description>	</description>
<LookAt>	
<longitude>	</longitude>
<latitude>	</latitude>
<altitude>	</altitude>
<range>	</range>
<tilt>	</tilt>
<heading>	</heading>
</LookAt>	
<StyleMap>	</StyleMap>
<Point>	
<coordinates>	</coordinates>
</Point>	
</Placemark>	

Fig.6. Format of KML files

3.3. Remotely configuring GPS receivers

There are several methods for configuring GPS receiver. The direct method is to set mobile GPS receivers manually. And the convenient method is to configure GPS receivers remotely through cell phones or system platform, that is, GPS mobile terminals can receive short messages via GSM networks and can parse and execute user-defined parameters and control commands contained in short messages. Some instructions used for conveying commands are listed in the Table 2.

According to the format of short messages, the contained contents can be analyzed and the control commands and parameters would be extracted and then used for resetting mobile terminals.

Table 2 AT Instructions

AT instructions	Functions
AT+CMGC	Send an SMS command
AT+CMGD	Delete SMS message
AT+CMGF	Select SMS message format
AT+CMGL	List SMS message from store
AT+CMGR	Read SMS message
AT+CMGS	Send SMS message
AT+CMGW	Write SMS message to memory
AT+CMSS	Send SMS message from storage
AT+CNMI	New SMS message indications
AT+CPMS	Preferred SMS message storage
AT+CSCA	SMS service center address
AT+CSCB	Select cell broadcast messages
AT+CSMP	Set SMS text mode parameters
AT+CSMS	Select Message Service

4. Experiments and discussions

4.1. Some system interfaces

Some key interfaces of Mobile Guardian are shown in the following.



Fig.7. System startup interface

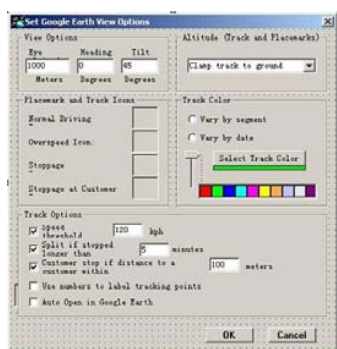


Fig.8. System configuration interface

The startup interface of Mobile Guardian is shown in Fig. 7. And users can set the parameters through the configuration interface and sub-interfaces displayed in Figure 8.

4.2. Single point testing

The district of Xiamen University is chosen to conduct the single point test. When mobile clients with the wrist-type terminal arrived at the destination, a short message contained the location information would be sent to the data post-processing platform. And the detailed coordinates about location would be extracted and then used for generating landmark files (KML), via which Google Earth showed the current position of the mobile client marked with a dot in the electronic map and all the specified locations marked with a balloon with a sequence number presenting the route.

Furthermore, administrators can annotate these locations different names manually. When users arrived at these locations, not only coordinates but also related-remarks would be visualized automatically in the electric map of system platform. When clicking corresponding points of interest, detailed information can be retrieved from databases. On the other hand, mobile clients can inquire current position by sending a specially formatted short message to the system platform. On successful handling short messages are returned back to mobile clients containing the semantic label of the current position and some other annotated information. The result of single point test is shown in Fig. 9.

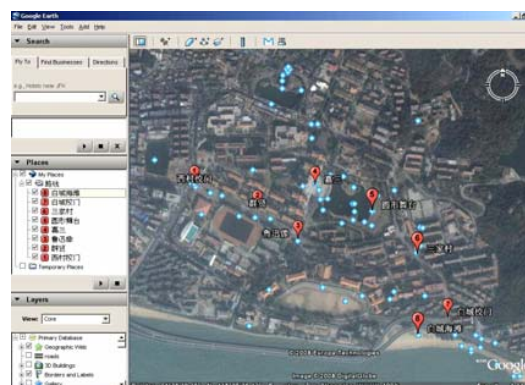


Fig.9. Single point testing result

4.3. Continuous points testing and routes generating

Some district in Canada is chosen to conduct the continuous points test. The result is shown in Fig. 10. When GPS receivers have been configured to send a fixed number of short messages reporting GPS position within a predefined time span, the movement path and direction can also be provided in form of a dotted line marking the points where users had been to. To visualize paths using different symbols, parameters, such as route color, width and etc can be configured. Moreover, the movement sequence in every path could be followed and listed in chronological order, as shown in Fig. 11.

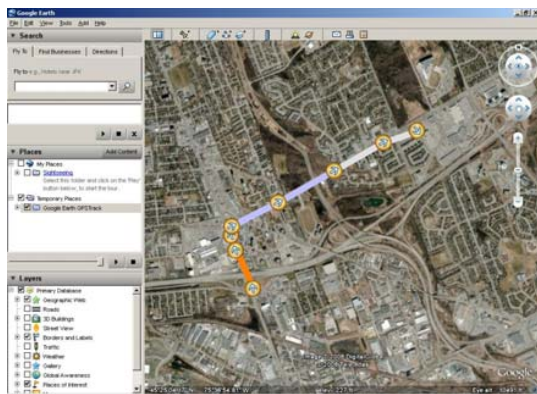


Fig.10. Continuous points testing result

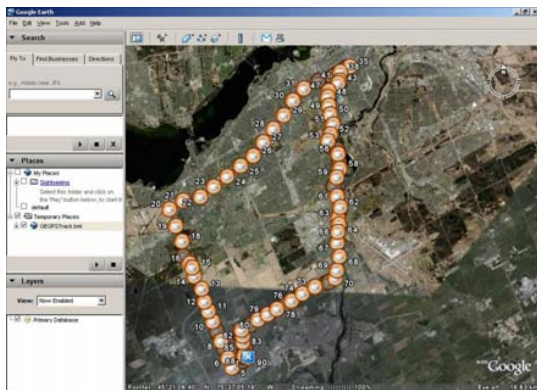


Fig.11. Labels of single point arriving sequence

5. Conclusions

Mobile Guardian is an important subsystem of the whole city GPS system. For outdoor special users such as mountaineers, juveniles, senile dementia and patients of accidental disease, Mobile Guardian can achieve the real-time and precise positioning and monitoring operations. And when emergencies occur, the wards can also send SOS to guardians or people around. Performed tests in this paper indicate that users can expect reliable results from Mobile guardian.

The novelties of the Mobile Guardian include low price, data-driven operation and demand expansibility. The thin client architecture in combination with mobile GPS receivers and Short Message Service was chosen in order to support a wide adoption in the market. It can be expected that improvements in positioning precision and regulations will further propel the supply and demand of GPS service for individuals.

6. References

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