A MONITORING SYSTEM OF AGRICULTURAL EQUIPMENT FIELD POSITION BASED ON GPS AND GIS
/
一种基于 GPS 和 GIS 农业装备田间位置的监控系统

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DOI: https://doi.org/10.35633/inmateh-62-24

Keywords: *GPS, GIS, agricultural equipment, field position, monitoring system*

ABSTRACT

With the development of communication technology and embedded technology, mobile intelligent terminals (mobile GIS) have become the key research direction of monitoring systems. In view of this, the study first constructed the structure frame of the agricultural monitoring system and the system mobile database, and designed the monitoring system terminal, combined with the .Net Compact Framework platform to implement the system functions, and finally the monitoring system based on GPS and GIS. The function of the system was tested. The results show that the system design of this study combines user needs' analysis, system framework and functional module division. The system design function realizes the function of creating a database, the entry and collection of attribute data and graphic data; and the editing and browsing of map data and management functions; it realizes the processing of data and the output of results, and displays in the form of graphs or reports; it realizes the functional modules of the monitoring system. It is hoped that this research can provide a certain reference and reference for the application of mobile intelligent terminals in our country's agriculture.

摘要

随着通信技术和嵌入式技术的发展，移动智能终端（mobile-intelligent terminals，mobile-GIS）已成为监控系统的重点研究方向。鉴于此，本研究首先构建了农业监测系统的结构框架和系统移动数据库，并设计了监控系统终端，结合.Net 网站紧凑的框架平台实现了系统的功能，最后对基于 GPS 和 GIS 的监控系统的功能进行了测试。结果表明，本研究的系统设计结合了用户需求分析、系统框架和功能模块划分。系统设计功能实现了建库功能、属性数据和图形数据的录入与采集；地图数据的编辑浏览和管理功能；实现了数据的处理和结果的输出，并以图形或报表的形式显示；实现了监控系统的功能模块。希望本研究能为移动智能终端在我国农业中的应用提供一定的参考和借鉴。

INTRODUCTION

With the increasing development of Internet technology, people have begun to be dissatisfied with the way to obtain information in fixed places, hoping that information can be obtained anytime, anywhere *(Zhang Sui et al., 2016)*. The development in the field of mobile computing is also getting faster and faster. Mobile information systems such as tablets and smartphones are gradually replacing traditional PCs, workstations and other clients, promoting the application of GIS in mobile terminals *(Holliday et al., 2017)*. Geographic information systems have also begun to gradually shift from indoor to outdoor mobile computing terminals. Mobile geographic information systems have become a research hotspot in the field of geographic information. Mobile GIS is a technology built on a limited level of processing and mobile computing terminals. This technology provides geographic information systems *(Agbalagba et al., 2016)* for entourage, mobile, and distributed information services. Based on GPS and GIS agricultural equipment field position monitoring system, which integrates GPS positioning and wireless technology, it is a monitoring system whose main purpose is to collect agricultural information. *(Li Y.B. et al., 2020)* The traditional geographic information system mainly collects and utilizes geographic information.

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Now that global positioning has developed to the stage of Mobile GIS, the real-time spatial location is added to the information collected by Mobile GIS. *(Wei W et al., 2020).* The system integrates different data of location information and collects it. The application value of the system becomes higher *(Xu Y.W. and Dong F., 2015)*. Nowadays, wireless communication has begun to be introduced into GIS systems. The wireless downloading, uploading and sharing of data has become a new field of GIS applications. The future research focus of Mobile GIS has become an information management system integrating collection, positioning and wireless.

Geographic Information System (GIS) is a multi-disciplinary integrated application subject, which involves map, geography, surveying, computer and other disciplines. With the support of computer software and hardware, systems engineering and information science are applied to three-dimensional space. Geographic information system can combine geographic attribute data with spatial data. Through data input, collection, operation, storage and other operations, the spatial information can be visually expressed, and various geographic information data can be detected at the same time. GIS has gradually become an indispensable facility in social information detection, and it has begun to penetrate all parts of life.

The innovation of this research is the combination of collected information and geographic images to build an efficient system based on GPS and GIS monitoring, so that users can get rid of the constraints of device location and transmission cables, users can apply various methods to the database, and this provides a reliable technical means for this study.

This study is divided into three parts. The first part is the research status of GPS and GIS monitoring technology at home and abroad. The second part is the design of agricultural equipment field position monitoring system based on GPS and GIS. The framework of agricultural monitoring system based on GPS and GIS is introduced in detail, including the construction of mobile database and the design of monitoring system terminal. The third part realizes and tests the main functions of the system. It includes map creation, data acquisition, data acquisition and data management. Data processing and result output are displayed in the form of graph or report. In addition, this part also includes the function modules of the monitoring system.

In recent years, the research based on GPS and GIS monitoring system has been highly valued by people. This technology has a profound impact on the future direction of social development. Researchers at home and abroad have also conducted in-depth research on this technology *(Yan H.W. et al., 2020)*. *Barrile V. et al.* established a processing tool that can perform a large amount of data processing and visualization by taking GPS measurements on the test bench, using GIS data processing tools, and combining traditional neural network artificial intelligence models *(Barrile V. et al., 2016)*. Issa ATE proposes a client/server solution, including two integrated databases, one for spatial data processing, and the other as a text database to store text coordinates of spatial data, and proposes a cache to improve system performance method *(Grzelak A. et al., 2019)*. *Mert B.A.* and others analysed the borehole data to generate digital map and table quality data, then used VISUALBASIC to write MapBasic computer application program in GIS environment, and finally combined the two. Finally, the digital monitoring of coal mining and extraction points was realized, and an inventory account and quality database were provided for coal production *(Mert and Dag A., 2018)*. *Cai M et al.* used the speed-density relationship method to estimate the traffic volume of GPS data of floating vehicles, and automatically output the attributes of roads and buildings from the GIS, establishing a regional traffic noise calculation model that considers the attenuation of urban traffic noise. The accuracy of the algorithm was verified by conducting traffic noise monitoring experiments in several areas of different road types in Guangzhou. The results show that the average error between the estimated value and the measured value is less than 2.0dB *(Cai M., Zou J. and Xie J., 2015)*. *Shahini Shamsabadi* and others introduced a road surface monitoring system PAVEMON based on GIS network. PAVEMON's Web-based GIS module was seamlessly integrated with the database to provide a reference for road surface survey data. Finally, information was obtained through PAVEMON, greatly increased pavement management capabilities *(Cunha D.G.F., 2019)*. *Tong Y. et al.* designed a real-time monitoring system for vehicle detection based on MapX, and introduced the system architecture and functional framework. Experiments show that the system is stable and efficient *(Tong Y. et al., 2016)*.

Brasington J et al. proposed a new method to study the three-dimensional morphological dynamics of gravel reach, using global positioning system (GPS) to perform topographic surveys on the exposed and flooded areas of the reach. The results show that the overall large-scale river structure has little change *(Brasington J., 2015)*. *Mishra A. and others* conducted a detailed soil fertility survey in the Bhadrak area of Odisha using global positioning system (GPS) and geographic information system (GIS) tools.

Using ArcGIS software to compile the soil fertility map of Bhadrak area, the soil fertility status was evaluated *(Mishra A. et al., 2017)*.

Choosumrong S. and others discussed the implementation of an open-source mobile geographic information system framework that uses a client-server model to meet the current need for data assimilation using smartphones. The entire system is implemented through free open-source software and open geospatial standards. Finally, it demonstrates the tracking and management of emergency medical service (EMS) vehicle driving conditions *(Choosumrong S. et al., 2016)*. *Zeybek M*. et al. combined resistivity tomography measurement, global navigation satellite system and ground laser scanning technology to monitor the landslide. The results show that the integrated technology provides a better means for monitoring the landslide process and collecting data to predict future movements *(Zeybek M. et al., 2015)*. *Akanwa A.O.* and others used remote sensing technology in the field of geographic information systems to determine the degree of impact of quarrying activities on vegetation coverage in the study area. The visual interpretation of the satellite image confirmed that the white patches on the image are areas affected by quarrying activities, and the dark green colour indicates no human activities observed in the forest *(Akanwa A.O. et al., 2017)*.

Through the research on the monitoring technology based on GPS and GIS, it can be seen that the research results of the monitoring technology based on GPS and GIS at home and abroad are still at a low level, and China's research work in this area is still in its infancy. The research of GPS and GIS monitoring technology needs to be expanded. In this study, the structure frame of the agricultural monitoring system based on GPS and GIS was first constructed, and the mobile database of the monitoring system was constructed, the terminal of the monitoring system was designed, and the various functional modules of the monitoring system were realized.

MATERIALS AND METHODS

Construction of agricultural monitoring system framework based on GPS and GIS

When constructing a monitoring system for the field position of agricultural equipment, the collection of agricultural equipment data is the key to the construction of the system. The data of agricultural equipment should be collected in real time for the operator to make decisions and analysis. This research is based on the position monitoring system of GPS and GIS technology, mainly to collect and record the information of agricultural equipment field position. In the design process, the overall design of the system is applied using UML top-level modelling, using the form of example diagrams to represent user needs, class diagrams representing object relationships, and timing diagrams representing interaction relationships. The system is composed of multiple parts. The most important part is a mobile GIS-based system that can provide data collection for the monitoring system.

The data collection process mainly includes starting maps, operations, navigation, spatial positioning, data collection, and transmission archive. In short, during the operation, turn on the GPS navigation function and path query function, move the map in the horizontal direction, keep the current position in the centre of the map, and select the appropriate display scale to facilitate monitoring operations. Next step is to collect the data: first select the type of data to be collected, the automatically generated points, lines and areas will be displayed on the map, and then the corresponding attributes will be entered for different spatial data. The above operations will be repeated until the data collection is completed. The collected data can be marked in the diagram for subsequent operations and processing, and the file can also be saved or transmitted. After all operations are completed, the monitored results should be saved in the database. The GIS server is used for communication in the saving process. The collected data is sent to the GIS and then stored in the database. The users of monitoring system data collection are mainly data collection workers. The functions that users can use include data collection, operation, deletion, editing, import, export and GPS navigation.

The monitoring system in this study can be run on mobile devices such as PDAs, with GPS as the low-level technical support. The system is an information collection system based on mobile device terminals. The main components of the system include GPRS communication, GPRS foundation, GPS, data acquisition and GIS terminal five modules. Among them, the GIS terminal can interact with GPRS and GPS modules respectively, and obtain data information from the serial port, and then transmit it to the upper layer application. The GPS module mainly provides data collection methods and can obtain positioning information. The main function of the GPRS module is to provide a wireless connection for the central server. The most critical part of the system is the embedded system, which can simplify the development of upper-layer applications and also shield the underlying hardware. The overall system architecture is shown in Figure 1.

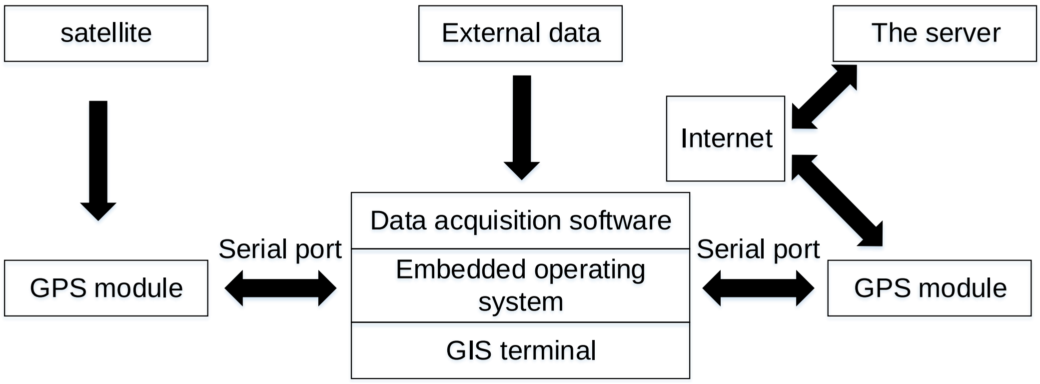

Fig. 1 - Overall architecture of the system

During the operation of the monitoring system, various types of collected data will be imported to a pre-made map to generate data objects. There are many application methods of data objects, which not only can be applied directly, but also can be used after being fused with the data in the original database. In addition, after processing the collected data, it can be added to the original base map to form a new base map. The information collection client is based on mobile smart devices, and users need to install client software on the mobile devices. This system adopts the object-oriented and modular design mode. The system mainly includes three modules: data storage, application services and user interface. The application service module mainly uses the mobile GIS component function, which can realize the basic functions of the map viewing operation, and realize the layer control and positioning sampling. The function of the data storage module is mainly to send the collected data to the central server. The GPS communication class library is mainly used for serial communication with the GPS receiver to process the received GPS data, as shown in Figure 2.

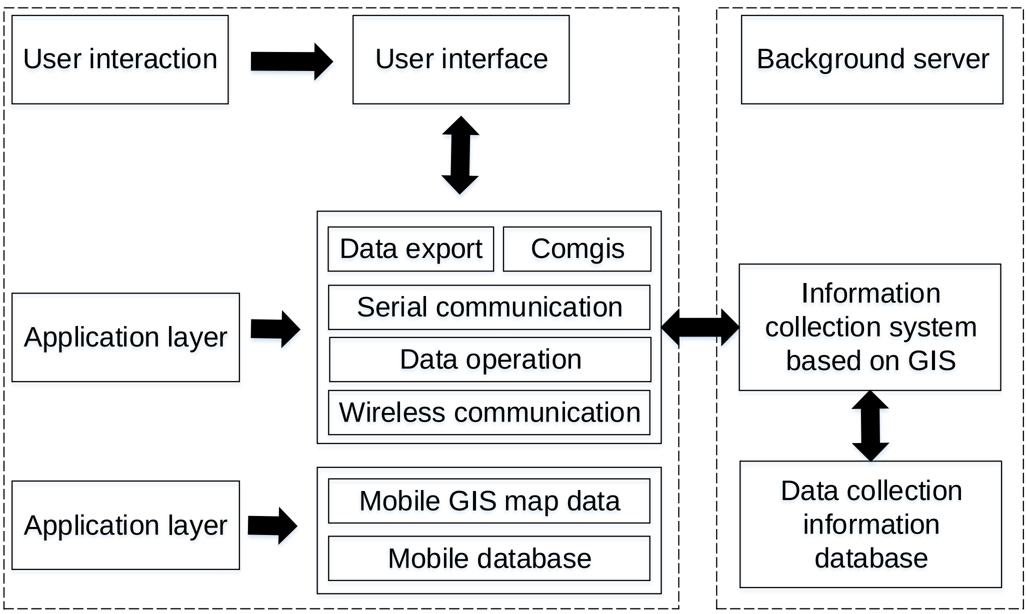

Fig. 2 - Monitoring system framework design drawing

The collection process of the monitoring system in this study can be summarized as the following processes. First process the acquired GPS, acquire the necessary data after processing, and then organize it by the mobile application layer, and transfer the organized data to the interaction layer. After acquiring the information, the user performs data-related operations and then processes it through the application layer to store the processed data in the database. The data is transmitted to the information monitoring system through the internal channel of the system, and finally the analysis-processed image is displayed on the client.

Construction of mobile database of monitoring system

Spatial information data is mainly GPS data and attribute data collected manually. These data require a unified database for storage. According to the actual situation of this research system, most of the data is attribute data, and a relational database should be used, so this study selected Microsoft SQL Mobile 2005 as the database. The main transmission method is wireless transmission, and wired transmission can also be applied. SQL Mobile does not run independently. It belongs to a server-side agent program. It requires IIS support and provides related services as an ISAPI process. Before accepting data, SQL Server database requires SQL Mobile to transfer data. At the same time, data reception on the device side requires SQL. Mobile performs data transfer.

SQL Mobile mainly includes two key technologies: remote data access (RDA) and rapid server response. RDA can perform remote access to SQL Server, perform query operations at the same time, and save query results to a local database. When operating on the local database, modifying data, etc., the update of these data information will be synchronized to the remote server database at the same time. The initiator of RDA is the client, and its data synchronization is unidirectional, and the client can only send synchronization requests to the server. The server can respond differently according to different requests; the quick response function of the server is based on the replication of the database server and merge mechanism, a response function added to the database server. This function can not only better support the data interaction between the remote server and the local mobile device, increase the automatic interaction service of the data, but also solve the conflict problem during data exchange. This function is more complex than RDA and requires more operations and configuration of the system, but its function is stronger than RDA and is more applicable in complex data application scenarios. The data design of this study included 7 tables, as shown in Table 1.

Table 1

Database form design

Form name	Representation
Basic information of sampling	DC-CY-BASIC
Collection point summary	DCYBJOINT
Property sheet of acquisition point	DCBJOINT CY
Sampling location classification table	DC-CY-REGION
Plot information statistics	DCTBCY-LAND
Crop information record form	DC-CY-CROP
Change of soil moisture	DC-CY-SOIL

Design of monitoring system terminal

The monitoring system in this study has a total of 6 modules, which are: map system setting, data maintenance, wireless communication, spatial analysis, collection, and operation. The collection module mainly collects data, and the collected content includes agricultural information, GPS coordinates and other data. In addition, point, line and surface data related to geographic information, agricultural equipment location, farmland area, positioning trajectory and other information data are also the information that this module needs to collect; after the original data collection is completed, the data maintenance module is required to maintain the collected data, The main function of the data maintenance module is to delete, modify and add data; the function of the operation module is to receive user instructions so that the user can directly operate the map. The main functions include area calculation, browsing and loading of the map; GPS function of the navigation module is positioning and navigation. The basic data is obtained through the serial port, matching the map and positioning information, and the navigation results and positioning information are calculated at the same time. The wireless transmission module is to import the wirelessly received data into the database.

The monitoring system is based on the HiMap platform to achieve spatial data collection, the platform provides a powerful interface for easy development of embedded GIS programs. At the same time, the hierarchical design mode is adopted, and the system design is divided into three levels. The first layer is the user interface layer, and the user can realize information interaction through the GUI interface; the second layer is the calling layer, which is composed of individual classes; the third layer is a domain class. This layer is complex to implement specific functions of the system. The overall mechanism design of data acquisition application software is shown in Figure 3.

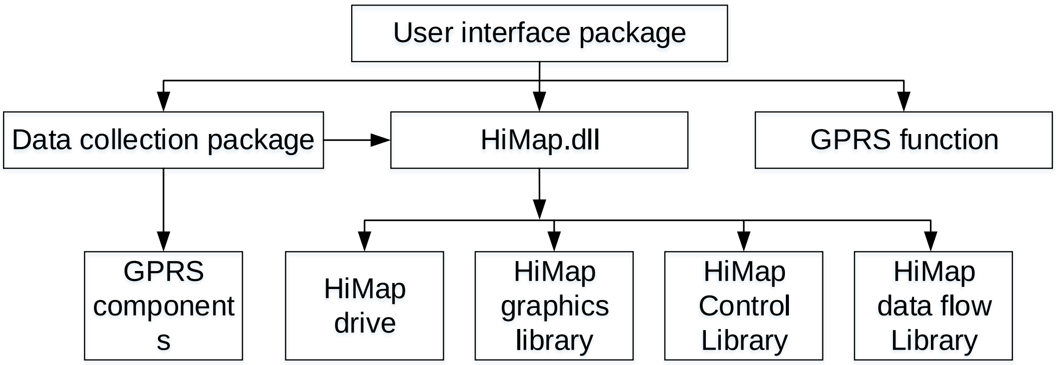

Fig. 3 - The overall mechanism design of data acquisition application software

There are many types of HiMap library, including data orientation, visualization, collection object, editing, path analysis and other types. All the functions of GIS are encapsulated in HiMap.dll component, GIS is the core of HiMap. There is a type of space mechanism in the driver, named HiMap for each object, and the location of the namespace is used for object search. The user interface package is composed of GUI components, and its function is mainly to display input and output information. The data collection package uses coordinates and communication information to modify the function library. In this process, the program interface must be referenced. The main function of the GPRS communication module is to connect the central server with the mobile intelligent terminal and is responsible for the reception and control of data signals.

RESULTS

Realization of the main functions of the system

In order to ensure the development of the monitoring system, this research requires a high level of system development environment. The design minimum requirements in terms of system hardware are as follows: computer hard disk 1024MB, CPU PXA310, memory 1024MB, operating system Windows Mobile 6, built-in Bluetooth adapter, mobile memory card 8G SD. The minimum requirements for the design of the software environment are as follows, toolkit Windows Mobile 6.0 SDK, operating system Windows XP SP3, synchronization software ActiveSync4.5, GIS toolkit HiMap net cf2.0, client database SQL Sever2005 Mobile Edition3.0, server database IIS +SQL Server2005+.Net2.0. The system design interface is shown in Figure 4.

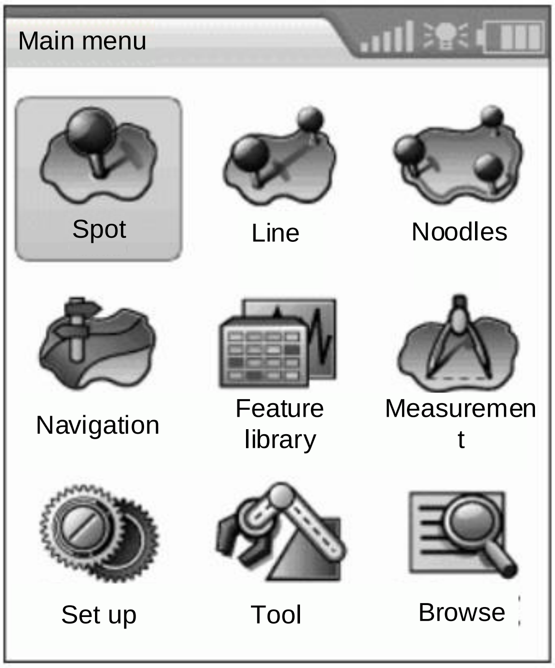

Fig. 4 - System design interface

This system design uses a variety of data storage methods and uses .Net Compact Framework to store system data, including SQL Mobile and XML. Import the collected information data into the database system, realize the wireless transmission of local data storage, and combine with the data tracked by GPS, and finally realize the data storage. The system realizes the GPS positioning data collection function connected with GPSID, through the NMEA0183 command analysis method, so that the system maintenance personnel can solve the NMEA commands. GPSID is a serial operation of the package, which mainly reflects the capability of the system, so that the data can be serially operated in the application program. Users can not only use GPSID to access GPS, but also obtain GPS information through the serial port.

There are two collection methods for users to choose from in the data collection module, namely automatic collection and manual collection. Among them, automatic collection requires the user to set the display scale, layer, data type, and collection interval in advance, and turn on the GPS data collection function, display the collected spatial data on the map, and prompt the data to be entered on the user interface Information, and then proceed to the next data collection. The corresponding implementation flowchart is shown in Figure 5 below.

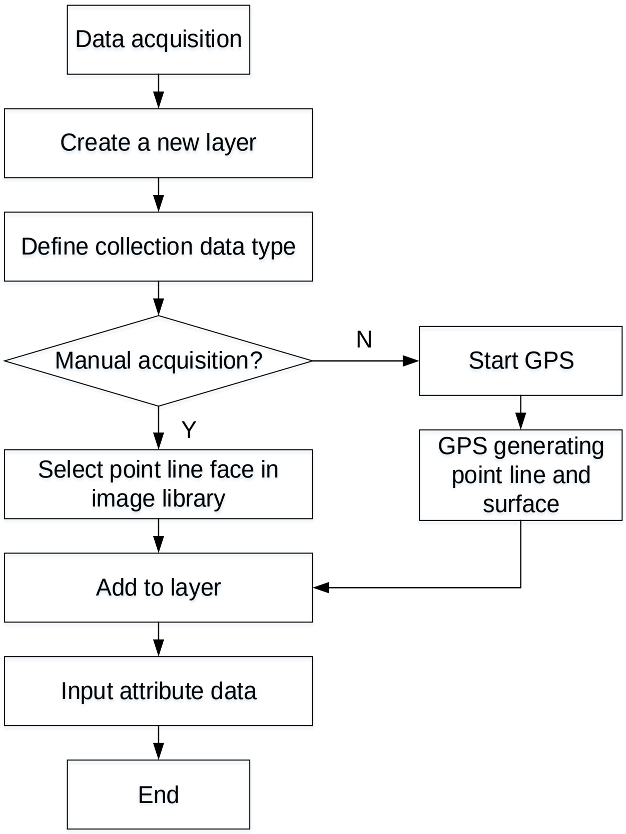

Fig. 5 - Flow chart of data acquisition module

System data query includes attribute and graphic data query. Attribute data query must first select the appropriate layer, set the object to be queried in the layer, and query in the attribute query window.

If a point is selected, the coordinate position of the point and the ID of the point will be displayed.

If a line is selected, the length of the line, the starting and ending position coordinates and the ID of the line will be displayed.

If the surface is selected, the area of the surface will be displayed, Coordinates and ID. Attribute data query should select the target object, and use SQL query method to perform conditional query in SQL.

If the query object is a point, the corresponding attribute of the point can be obtained.

If the query object is a face, then the size of the query area needs to be set, and the attributes of all objects in the area need to be counted.

System module test

In order to verify the realization of the system data, the system module is tested on the system. Select the basemap that needs to be analysed in the system. If you use manual acquisition, you need to select the type of object to be collected. It is one of points, lines, and areas. Select the type of data you need and add it to the corresponding position of the bottom map.

If you need to output the new basemap, you need to print the basemap, if you want to continue to query, you can store the basemap to the symbol library; if the user chooses to automatically collect, then the system will start GPS from the serial port, set the collection attributes, collect the target data through GPS, and display it on the base map. At the same time, GPS will automatically process the points, lines and planes and display them on the layer. To add attribute data on the image data object and submit data information, the test process is shown in Figure 6.

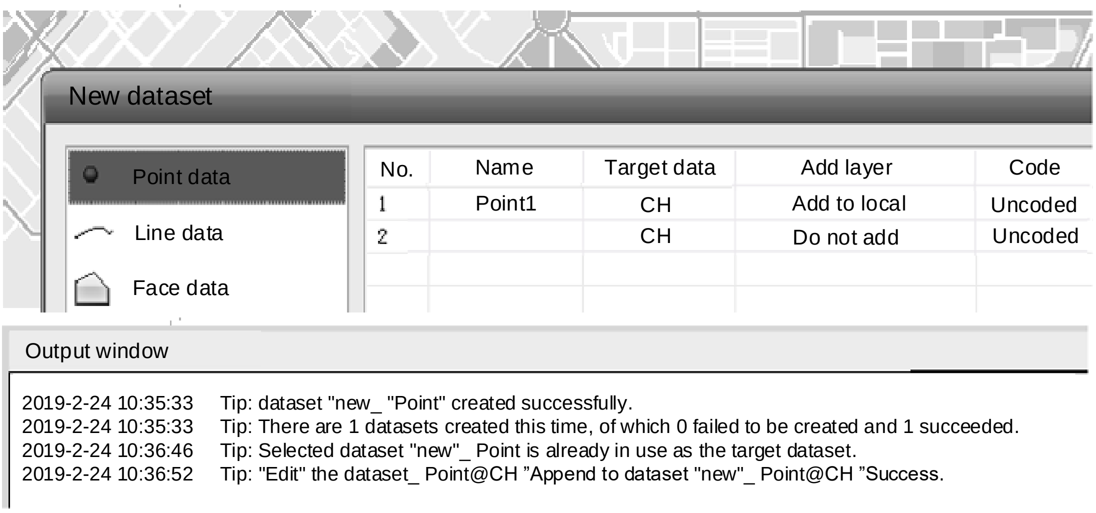

Fig. 6 - Data collection results

The symbol library management module can call and view the symbols in the point, line and area library, and can also add newly designed symbols in the library. As for the layer control of the data management module, it completes the layer attribute setting, realizes layer modification, deletion, addition operations, and outputs the object information of the layer. The data query function realizes the query function of attributes and graphics. When the graph query function selects a certain area or feature, it will automatically display the attribute information of a certain area or feature. The user sets the query conditions and then accesses the file; database is accessed and the query results are obtained. For the map browsing module, this module provides the zoom, move, and browse functions of the map, and all functions can be realized by clicking.

Fig. 7 - Positioning of agricultural equipment monitoring equipment

As shown in Figure 7, in the process of positioning data collection, for the realization of the data editing module, the database data set is actually operated, and the filling of the attribute form is used to modify the relational database to complete the attribute data editing function. For the implementation of the output module, the original or created data object is output in the set format, the image is stored in the .smw format, and the attribute data is output in the form of a table.

CONCLUSIONS

Aiming at the technical problems of agricultural machinery field positioning monitoring, the system structure framework, system mobile database and monitoring system terminal were designed, and the system was implemented and tested on the. Net compact framework platform. The results show that this research has completed the layer attribute setting, realized the layer modification, deletion, addition operation, as well as the layer object information output. It not only realizes the query function of attribute and graph, but also realizes the output of original created data object in the set format. The image is stored in. SMW format, and the attribute data is output in the form of table, so as to provide the functions of map zooming, moving and browsing. Through the system design function, it shows the database creation, data attribute processing and graphic data input and collection functions, including map data editing, browsing and management. The data processing and output are displayed in the form of graphics or reports, which clearly shows the various functional modules of the monitoring system. Due to the limited time and ability, this study also has some deficiencies. There is little research on image data acquisition, so it is necessary to further improve the system for this kind of data acquisition. In the future research work, we will pay more attention to this aspect.

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