

Research Article

Design and Realization of Land Reserve Multimedia Information Management System Based on GIS

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In order to promote the orderly development of cities and realize social public interests, a design method of a land reserve-oriented multimedia information management system is proposed. It is of great practical significance to integrate and sort out the whole process of land reserve projects through spatial information platform, effectively manage land reserve, land supply, and planning information, improve the utilization rate of land resources, and provide information support and decision-making basis for land expropriation and land registration and certification. By combining scattered information resources, integrated into a unified information service platform, realize the unified update and maintenance of all kinds of data, increase the reusability of data, and avoid data synchronization between the two levels of urban land reserve departments and the resulting waste of resources. After three tests and modifications on 50 devices, successfully increased the operation success rate from 86% to 100%, and a complete and effective land reserve multimedia information management system has been successfully developed. In order to better do the handover and transition of the reserve work, it is necessary to integrate, update, and improve the historical and existing reserve projects and build a unified and standardized land reserve geographic information database, so as to effectively promote the sharing and application of information resources.

1. Introduction

The informatization and paperless construction of land resource management is not only one of the key construction contents of “digital city” but also one of the key contents of e-government construction [1]. The transformation of government functions and the increasing maturity of computer technology, there is an urgent need for land resource management to develop in the direction of informatization, scientification, standardization, and public service. Looking at the current situation of informatization construction in various places, it is still not optimistic [2]. Many places still use the traditional work model and use paper media to record and store relevant data, the process is cumbersome, registration is difficult, access is inconvenient, digitalization is low, management is chaotic, and this leads to low work efficiency [3]. Therefore, in order to improve the level of land management informatization, in the construction of the geospatial framework of the digital city with the land

administration department as the lead unit, both will build a land resource management information system, listed as one of the typical demonstration application system construction. On the basis of careful analysis of the above background, the process of land resources business and daily management was sorted out, researched how to structure and construct the land resource management system [4]. The theory and method of basic spatial data construction are systematically studied, and the framework of the land resource management information system is established; also, use C# as the development language, with Oracle11g as the data support platform, and based on the ArcGIS platform, the development of the land resource management information system has been realized, so as to meet the needs of the daily work process of various departments [5]. Taking into account the goals and functional requirements of the system construction, and the current international and domestic technological trends in the construction of “digital cities,” combining the actual situation and taking

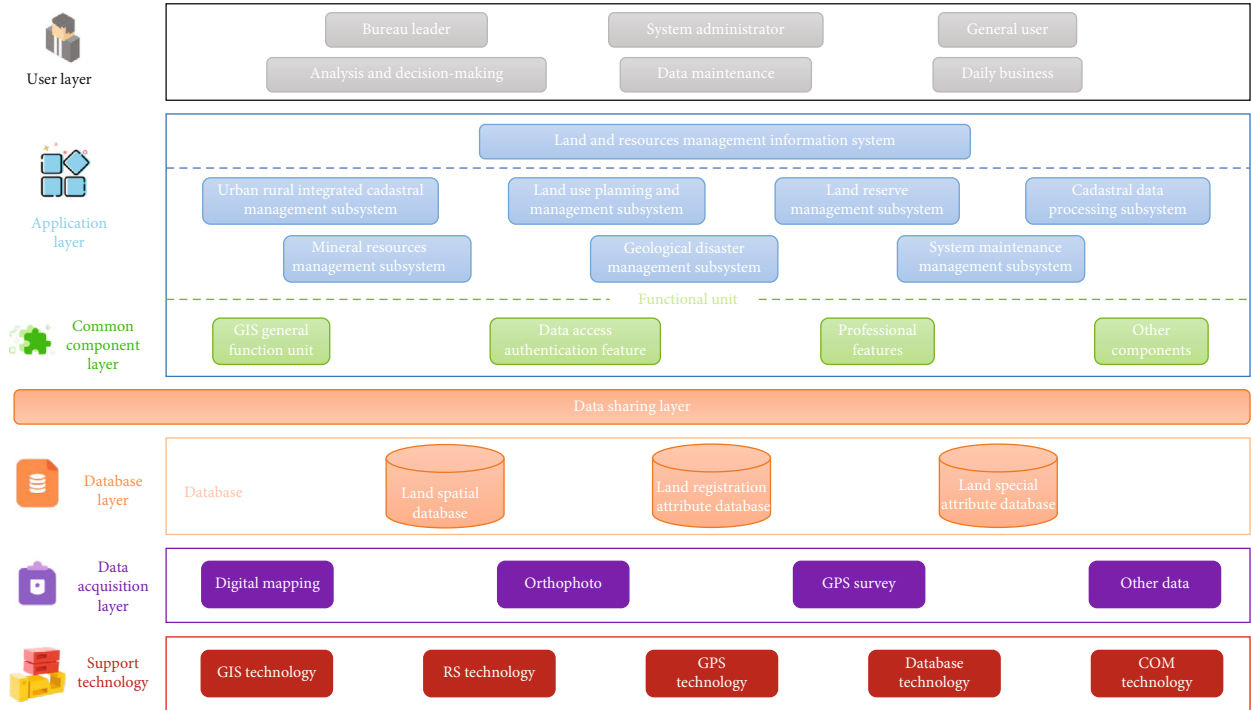


FIGURE 1: The overall technical framework of the system.

into account the actual needs of the system, it is in line with the technology of the future informatization framework, and Figure 1 shows the overall technical framework of the system.

GIS technology is a comprehensive crossdiscipline, it mainly involves many subjects such as graphics, vision, and database, and because GIS has unstructured data and powerful spatial analysis functions, it is different from general information systems: Geographic Information System (referred to as GIS) and Computer Aided Cartography (referred to as CAD); there is a big difference between the three database management systems (DBMS) [6]. The advantage of computer-aided drawing is that it has a relatively strong ability in graphics processing, and the disadvantage is that it cannot handle complex spatial relationships; moreover, the processing of massive spatial data is also weak. Database management system generally used to store and manage structured data; however, there are relatively large defects in the query, management, analysis, and display functions of graphics. The data involved in the GIS system is mainly composed of two parts: spatial data and attribute data; through the combination of the two, spatial entities can be expressed. The types of spatial data mainly include point features, line features, and area features, and attribute data is mainly a collection of auxiliary information used to express spatial entities [7].

2. Literature Review

In response to this research question, Mwangi and others, under the guidance of the city's master plan, land use plan, and land reserve plan, use GIS technology to build a

dynamic, integrated, and all-element land reserve dynamic management model that covers the entire region, strengthen the connection and sharing of land reserve information and planning land management information, and improve the overall process control ability of reserve work plan preparation, operation procedures, work standards, and information management [8]. Zhou and others stated that the dynamic management and monitoring of land reserves are a long-term task, through the establishment of a land reserve project data management mechanism, which systematically understands the status of land reserves in various regions, so as to fully carry out land reserve supervision work [9]. Norgrove and others sorted out the reserve process of the land reserve project, achieve full coverage of land reserve projects, comprehensively reflecting the implementation information of project approval, business implementation, capital management, etc., and realize the real-time update of the reserve project data [10]. Vries. et al. proposed, on the basis of sorting out and categorizing the business links of land reserve, pay attention to business management standard design and process optimization and unify the business standards of various reserve agencies and standardize the implementation of land reserve projects [11]. Buchanan and others built a spatial geographic database of land reserves through research, according to the internal logic of different dimensions and data such as "time, region, topic, and level," and reintegrate the data resources that have been mastered [12]. Nguyen. et al. said to build a land bank database that can be flexibly configured and managed and dynamically updated and backed up, through data extraction, parallel database processing, and other technologies, make decentralized data a logically centralized land bank

data system, realize the unified management, calling, analysis and operation, and maintenance of data, and further enhance the support and guarantee capacity of land reserve work [13]. Ramesh et al. conducted completeness checks on the accumulated project data, land use status data, planning data, and remote sensing image data accumulated over the years and generate a detailed list of existing data [14]. Based on this, Epstein et al. organize data according to unified requirements, including standardized processing, data item supplementation, data format conversion, coordinate conversion, topology reconstruction, data storage, construction of data index, establishment of data dictionary, and maintenance of metadata [15]. Hameed et al. stated that land reserve is a large-scale land acquisition, consolidation, and supply plan and has a substantial impact on the city's development patterns and land prices, and it is the main means to regulate and regulate the land market, promote the orderly development of cities, and realize social public interests [16]. Pramadi and others, through the integration of spatial information platforms, and sorted out the whole process of land reserve project, effectively managed land reserve and land supply and planning information, improve the utilization rate of land resources, issue certificates for land acquisition and land registration, and provide information support and decision-making basis, and it has strong practical significance [17]. Recently, with the rapid development of computer information technology and social economy, as well as the in-depth understanding of the informatization of e-government management by the land department, the demand for informatization is increasing day by day. Many precious experiences have provided the basis for the construction of the land and resource management information system.

3. Methods

3.1. Design of the Land Reserve Multimedia Information Management System. The overall goal of the system is summarized in the following two points: (1) relying on the geographic information public service platform, integrating cadastral, land use status, planning, minerals, geological disasters, and other multisource information and establish a thematic database of land resources, in order to be able to meet the requirements of "a picture" management; (2) combining land office business, build a system that combines GIS and business processes, realize the operation of land office business that can combine graphics and text, and improve the efficiency of land management [18]. The construction of a land resource management information platform is very difficult, involves more disciplines, and requires higher professional standards, mainly related to network communication, geographic information system technology, spatial database technology, spatial data update and information release, etc., in order to achieve the system design goals, in the whole process of system construction, and we always follow the relevant specifications of software engineering, do a good job in user needs, overall design, and detailed design, and gradually implement, tested, and perfected, in the construction of the system, "advanced and

efficient" that should also be used as the basic criteria to establish a "massive, open, safe, convenient and friendly" system architecture. The territorial spatial database organizes spatial data according to the Geodatabase data model of ArcSDE [19]. The Geodatabase data model recognizes, organizes, manages, and applies spatial data according to its own spatial logical relationship, and it greatly facilitates the use of spatial data by users and maximizes the function of spatial data. This system involves a lot of data content, and the amount of data is large, from a classification point of view, including three database contents: land space database, land registration attribute database, and land special attribute database, such as Table 1: system database.

In the land spatial database, it is based on the cadastral topic, land use status, and planning topic described by the vector data structure, the subject of mineral resources, the subject of geological hazards, and other five major thematic elements, including the spatial relationship of spatial data objects and related attribute information. The land registration database stores the forms filled in when the country's land registry is issued, mainly for the office of the Cadastral Division of the Land and Resources Bureau. The national land special database stores the attribute tables of other special businesses; at present, the main data content is index data and document information related to land use planning, it is mainly for the Planning Division of the Municipal Land and Resources Bureau, and other special data can be added later as needed [20].

The land and resource management system is based on system construction goals and tasks, according to the business jurisdiction and its geographic information requirements, and divides the entire information system into the following 7 subsystems: urban and rural integrated cadastral management, land use planning management, land reserve management, cadastral data processing, subsystems such as mineral resource management, geological disaster management, and system maintenance management. In this system, the subsystem and the subsystem are relatively independent, but at the same time, it also cooperates with each other and can achieve information sharing [21]. The specific division structure is shown in Figure 2: system division structure diagram.

In order to achieve nonoverlapping functions between various system applications, realize the reuse of components, and the system adopts modular software design and component design ideas, reduces development workload and facilitates system maintenance, thereby reducing development costs, and improves software productivity. The software reuse of functional modular design is based on the reuse of binary code, and all operating platforms that support COM and other components can be shared. In the development process of the system, the functions of the system are mainly displayed in the form of UI [22]. Therefore, UI acts as a bridge between humans and computers and plays a vital role, and the effect of the design greatly affects the user's evaluation. If the developed system interface can be friendly and easy to operate, it is a good thing for users. If you want to make the designed system interface meet the user's requirements, on the one hand, it is necessary to make as perfect as possible the functions realized by the system; on

TABLE 1: System database.

Serial number	Name	Logo	Main content
1	Land spatial database	TDUSER	Cadastral, land use status, land use planning, mineral resources, and other data
2	Land registration property database	TDDJSJK	Land registration receipt, application, investigation, approval, and other business process data
3	Land special property database	TDZXSXK	Special data such as land use planning text and indicators

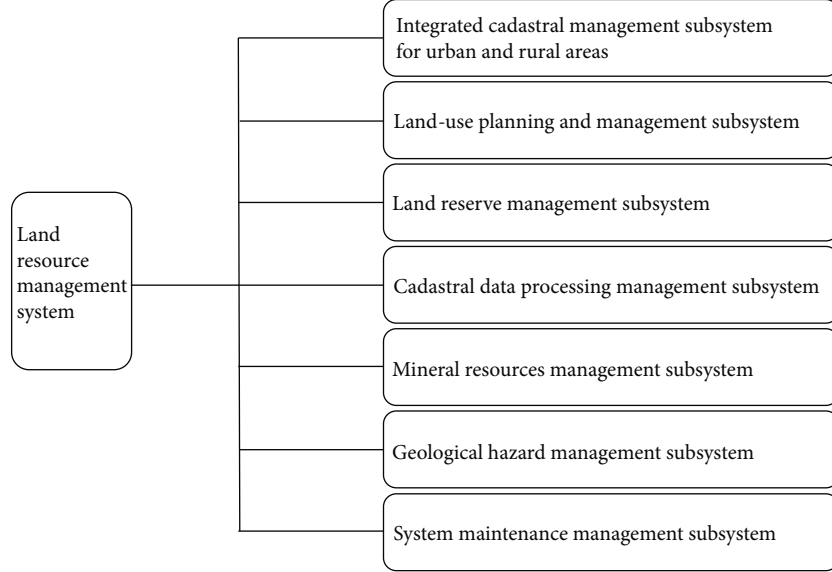


FIGURE 2: System partition structure diagram.

the other hand, you have to design the interface, as far as possible in line with the user's operating habits [23].

Step 1. According to the conditions of the principal component mathematical model, F_i and F_j are uncorrelated with each other $i \neq j, i, j = 1, 2, \dots, p$, and the principal components are required to be uncorrelated with each other. For this reason, the covariance matrix between the principal components should be a diagonal matrix. That is, for principal component (1),

$$F = AX. \quad (1)$$

Its covariance matrix should be (2)

$$\text{Var}(F) = \text{Var}(AX) = (AX) \cdot (AX)' = AXX'A'. \quad (2)$$

Step 2. Let the covariance matrix of the original data be V . If the original data is normalized, the covariance matrix is equal to the correlation matrix, that is, (3):

$$V = R = XX'. \quad (3)$$

The third step is based on the conditions of the principal component mathematical model and the properties of the orthogonal matrix. If the conditions can be met, the best requirement is to be an orthogonal matrix, that is, to satisfy (4)

$$AA' = I. \quad (4)$$

Then, substitute the covariance of the original data into the covariance matrix formula of the principal components to get (5) and (6):

$$\text{Var}(F) = AXX'A' = ARA' = A, \quad (5)$$

$$ARA' = \Lambda. \quad (6)$$

In order to obtain the solution of the homogeneous equation, the determinant of the coefficient matrix is required to be 0, as shown in the following equations (7) and (8):

$$ak_1^2 + ak_2^2 + \dots + ak_p^2 = 1 \quad k = 1, 2, \dots, p, \quad (7)$$

$$|R - \lambda_1 I| = 0. \quad (8)$$

Similar equations can be obtained from the second column, third column, etc.; so, λ_i is equation (9):

$$|R - \lambda I| = 0. \quad (9)$$

The variance relative to F_i is

$$\text{Var}(F_1) = a_1 XX' a_1' = a_1 R a_1' = \lambda_1. \quad (10)$$

TABLE 2: Parcel mapping test cases.

(a)

Test module number	LRMGIS.ResultOutput					
Test environment setup	Windows 7, Oracle11g					
Test case description	Output the parcel thematic map of the specified cadastral number					
Test prerequisites	There are layers of parcels, boundary points, and boundary lines					

(b)

Use case number	Testing purposes	Steps	Enter	Checking point	Expected output	Actual output
1	Output the parcel thematic map of the specified cadastral number	1. Select the function of [cadastral number export map] in the toolbar of [map output toolbar]	Mouse click	[Picture of parcel] can the window pop up normally	Pop up normally	Pop up normally
		2. Enter the cadastral number in the [cadastral number] input box	Mouse click, keyboard input	Observe whether the cadastral number is entered correctly	Entered correctly	Entered correctly
		3. Click the [OK] button with the mouse	Mouse click	Can the thematic map of parcels be exported successfully	The output is successful	The output is successful
		4. Mouse click the [cancel] button	Mouse click	Whether to successfully exit the plot output function of the parcel	Exit successfully	Exit successfully

TABLE 3: Planning preaudit analysis test case.

(a)

Test module number	LRMGIS.ResultOutput					
Test environment setup	Windows 7, Oracle11g					
Test case description	Calculate whether the designated area meets the plan					
Test prerequisites	Planning related data exists					

(b)

Use case number	Testing purposes	Steps	Enter	Checking point	Expected output	Actual output
2	Calculate whether the designated area meets the plan	1. In the [statistical analysis] toolbar, select the [planning prereview] function	Mouse click	[Planning prereview] can the form pop up normally	Pop up normally	Pop up normally
		2. In the [planning prereview] form, select a method to establish the analysis area, select the data to be analyzed, and click the [analysis] button with the mouse	Mouse click	[Planning prereview results] can the form pop up normally	Pop up successfully	Pop-up dialogue box
		3. In the [planning prereview results] form, click the [output to review form] button with the mouse	Mouse click	Can the analysis result be successfully exported to excel	Successfully exported	The result is correct

3.2. Realization of the Land Reserve Multimedia Information Management System. In the system, the design of the communication contract interface is mainly through three interfaces:

IApplication (host program interface), IPlugin (plug-in object interface), and IPluginService (plug-in framework interface). The design of system functions mainly adopts the idea of

TABLE 4: Initial registration test cases.

(a)

Test module number	LRMGIS.ResultOutput
Test environment setup	Windows 7, Oracle11g
Test case description	Carry out land certificate processing on the parcels
Test prerequisites	There are forms related to registration and issuance

(b)

Use case number	Testing purposes	Steps	Enter	Checking point	Expected output	Actual output
3	Export the land certificate for parcels	1. Select the [registration issuance] function in the [land registration] toolbar	Mouse click	[to do query] can the form pop up normally	Pop up normally	Pop-up dialogue box
		2. Select the business process to be input in the [business process] list and click the [new] button with the mouse	Mouse click, keyboard input	Can the [receipt form] pop up successfully	Pop up successfully	Pop-up dialogue box
		3 Fill in the relevant information in the [receipt form], [application form], [application form], and [approval form] forms and click the [save] and [submit] buttons in turn with the mouse	Mouse click	Can you successfully export the parcel thematic map	Pop up successfully	Pop-up dialogue box
Remark		In the to-do query window, double-click to continue the land certificate issuance business, and the process is similar to the above				

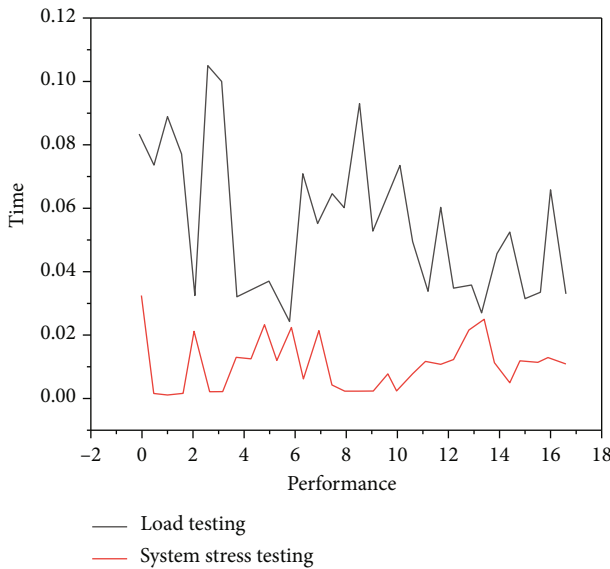


FIGURE 3: System performance test analysis.

component development mode, and the basic idea of component-based development components is as follows: divide software applications that are large and complex, or have the same functional modules, into a series of unit components that can be implemented first and are easy to develop, understand, and adjust. Take GIS secondary development platform ArcEngine development components as an example, it provides map display control AxMapControl, cartographic control AxPageLayoutControl, layer control AxTOCControl

and toolbar control AxToolBarControl, and other general controls, it is the use of component-based development technology, which makes in the process of GIS system development, by directly dragging and dropping these controls onto the form, and a simple GIS system can be implemented [24]. Based on the author that puts in the land resource management information system, common functions of each subsystem (such as map browsing, map query, map mapping, and spatial analysis) are extracted and packaged together in the form of plug-ins, which is equivalent to a higher-level component; then, when each subsystem needs these functional modules, as long as the corresponding plug-in and the generated DLL are placed in the specified folder, the goal can be achieved, so as to avoid unnecessary duplication of development work, and improve development efficiency [25]. The system is collected in the style of office2010, closer to the operating habits of the staff, the system is mainly composed of 7 parts, and they are the menu bar, layer manager, map display, thumbnails, status bar, map right click, layer right click, etc. [26]. The following are the specific functions of these 7 components:

- (1) The menu bar is mainly used to store the functions of each subsystem, such as map tool bar, map query tool, result output, thematic map, and land registration
- (2) The layer manager is used to manage land-related spatial data
- (3) The map display is mainly used to display land-related data, spatial positioning, spatial analysis result data, etc.

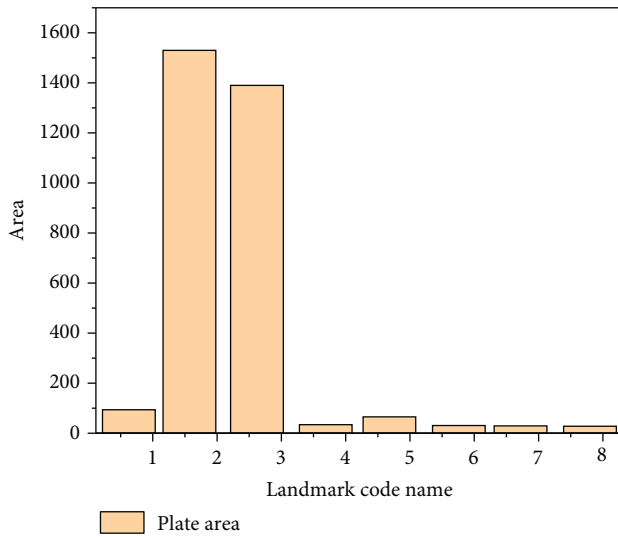


FIGURE 4: Classification statistics of map spot area.

- (4) The function of the thumbnail is similar to looking down from the air, browsing the map displayed in the map display, and the position in the entire map
- (5) The status bar is used to display the current user's operations in real time and to display the coordinates of the current spatial position of the mouse
- (6) The right button of the map provides the operation function of the map, such as panoramic view, previous view, next view, map zoom function, select elements, clear elements, create polygon elements, and boundary point result table
- (7) The right button of the layer provides the operation function of the layer, such as symbolizing, deleting layers, zooming to layers, viewing attribute tables, optional and nonselectable layers, set labels, display labels, and layer attributes

4. Results and Analysis

According to the system design content, this test intends to test the following system modules to test its functions: parcel mapping, planning prereview analysis, initial registration, and other functional modules, and the test methods for other functional modules are similar to [27]. Parcel mapping function is mainly to verify whether the input given cadastral number successfully outputs the corresponding parcel, boundary point, and boundary line, and whether the style is correct, and the result can be obtained from the test case of plotting in Table 2 that is correct.

Planning preaudit analysis function mainly verifies whether there is planning-related data in the designated area, so as to determine whether the area meets the planning; from Table 3 planning prereview and analyzing test cases, it can be concluded that the results are in line with the actual situation.

In initial registration function, the main verification is to enter the given cadastral number, whether the relevant cadastral information is successfully displayed, from the relevant operations of land application, and from the initial registration test case in Table 4, the correct result can be obtained.

Performance testing is to check the system, whether it meets the performance specified in the requirements statement, it generally includes load testing and system stress testing, and there are mainly SEI load test planning process, RBI method, performance decline curve analysis method, and HP (LoadRunner) performance analysis method [28]. The author has a dynamic management system for construction land and performed a performance test, and the test tool selected is LoadRunner, as shown in Figure 3 for the analysis of the performance test.

Statistics on the classified area of map spots, it is used to count the number and area of the first and second level map spots in a certain administrative region. In the "Select Administrative Level" item, the administrative district name of the current map will be automatically read and add it to the drop-down box. After selecting the administrative level to be counted, click the "OK" button, and the system will automatically perform statistics and display it in the form of a statistical graph. Click on the tabs such as "Statistics on the area of the first-level map" and can switch to display different statistical content, in the "Statistical Graph Type" in the lower right corner, and you can select the type of the displayed statistical graph, as shown in Figure 4, spot area classification statistics.

5. Conclusion

Software environment is as follows: the server system adopts windows server 2008 or above and Internet Explorer 7.0 or above. The client system adopts windows XP professional and Internet Explorer 7.0 or above. The database server uses Oracle9i. The spatial database engine is ARCSDE9.2. The GIS client is ArcGIS Engine, along with firewall and real-time virus monitoring. Hardware environment is as follows: application server configuration is Intel 1.66GHz or higher, RAM4G, hard disk above 160G, UPS, 17-inch (resolution 1024*768) or above display, 100 M network card. Client configuration is Intel 1.66GHz or higher, RAM4G, hard disk above 80G, 100 M network card. We have repeatedly tested and modified the completed system; for the first time, when 50 computers were running at the same time, 4 of them had a system crash, there were 2 systems crashed and stuck, and 1 was unable to run the software, and the success rate was only 86%, and after that, we modified the system and tested it again; for the second time, only 2 computers were left to crash occasionally; so, the last rectification was carried out, and finally, in the third running test, the running success rate reached 100%. In research, the current status and results of the development of new media information system for land resource management are based on GIS, and combined with the current actual situation, in view of the daily work needs of relevant land management departments, the overall framework of the construction of the land resource

management information system is proposed. And on this basis, they introduced the land resource management information system, the key technologies adopted, and the composition, functions, and implementation methods of the system, adopt plug-in type, ArcGIS Engine, ArcSDE, Oracle11g, and C/S network structure method, and developed a land resource management information system, so as to meet the daily work flow needs of various departments of land resources. Due to actual needs, this system is based on the C/S structure, without the research and development of the WebGIS function module. In the future, the WebGIS module can be strengthened, or the C/S and B/S structures can be combined.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that she/he has no conflicts of interest.

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