City appearance environment management system based on WebGIS

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ABSTRACT

With the continuous expansion of the city scale and the acceleration of the urbanization process, urban environmental governance has become more and more important. To meet the needs of urban environmental information management, a WebGIS and information data visualization technology is proposed to analyse the city's appearance and environmental information system. A city appearance and environment management system covering the functions of map display and basic operation, real-time display of city appearance and environment information data, statistical analysis, is built by using technologies such as leaflet, ArcGIS API for JavaScript, Java. Taking the main urban area of Changchun as the research area, this paper introduces the system structure design, the main technology of system development and the system function design in detail. Using this system can not only help city managers to provide effective information, but also provide information for city appearance and environment information management and Intelligent construction provides technical support.

Keywords: WebGIS, ArcGIS API for JavaScript, Leaflet, Java

1. INTRODUCTION

With the rapid development of the domestic economy and the increasing level of urbanization, a good city appearance environment is not only conducive to building a civilized and liveable city, but also can promote the rapid development of urban economy[1]. Due to the continuous expansion of urban area and population, many urban appearance and environmental problems will inevitably occur, resulting in increasing pressure on urban management. This city's appearance and environmental problems will not only affect the beautiful environment of the city and the traffic travel of residents but also may lead to traffic accidents and criminal crimes in serious cases. With the rapid increase of urban appearance and environmental problems, the traditional urban appearance and environmental management methods cannot meet the needs of Urbanization.

In view of these problems, this paper designs and implements a city appearance environment management system based on WebGIS by combining Vue, Mybatis, SpringBoot and other open source frameworks. The system has the mechanism of unified access to service spatial data and database business data, and has the function of unified management role authority, data authority and function authority. It can record the user's operation of using the system and access to service spatial data in the log, and can effectively help urban management personnel improve urban governance efficiency[2].

2. SYSTEM DESIGN

2.1 Related technology

The system is implemented based on WebGIS, using ArcGIS Server to publish and manage layers, stores spatial data in PostgreSQL database, stores system business data in MySQL database, and realizes unified access to data by configuring multiple data sources at the back end. The front-end map visualization adopts ArcGIS API for JavaScript + Leaflet technology, and combines with Vue.js, Java, Spring, Mybatis, and other open-source frameworks for system architecture and development.

2.2 Overall architecture

The system is developed with B/S architecture, and the overall structure of the system is shown in Figure 1.

(1) Client layer: corresponding to the web browser, install the web browser client, log in to the city appearance and environment information system according to the system account and password, and realize the functions of the system.
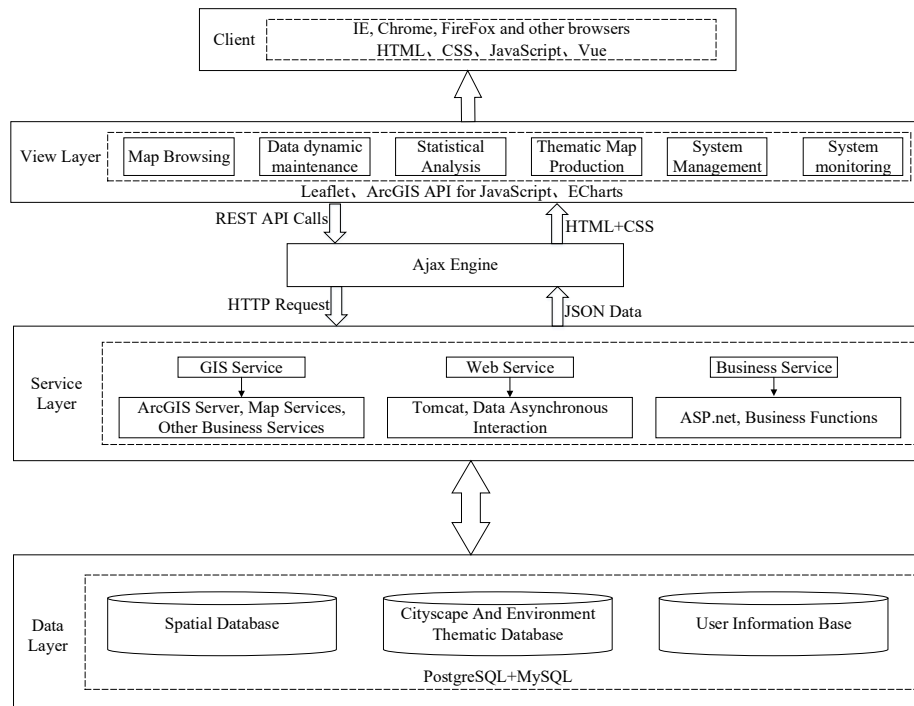
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Figure 1. Overall architecture of the system.

(2) View layer: it is mainly used to interact with the client users by using Leaflet and ArcGIS API for JavaScript class library and Vue framework, and mainly realizes the functions of city appearance and environment problem map browsing, dynamic maintenance of city appearance and environment data, special statistics of city appearance and environment problems, production of special map of city appearance and environment problems, and system management and system monitoring;

(3) Service layer: mainly refers to the technology and services required for system implementation. Axios is an HTTP Library Based on promise. The client and server interacts through Axios technology. The service layer mainly includes GIS services and web services[3]. It is responsible for receiving requests from the client for map data processing, such as data management of urban appearance and environment issues, thematic statistics, and production of thematic maps. The GIS Server uses ArcGIS Server 10.5 to manage and schedule various GIS resources and package them into services so that they can be presented to client applications through REST API[4]. The web server uses Tomcat built in SpringBoot to host web applications and services, deploy external network access, and return data processing results for users to browse; Other business functions are realized through ASP. NET.

(4) Data layer: The data layer is the basic support for system data management, including geospatial data, business data, and system management data. The system uses PostgreSQL with MySQL database to store spatial attribute data, business data, and user data respectively. The database structure is shown in Figure 2.

2.3 Module division

The system is divided into modules such as city appearance and environmental map browsing, city appearance and environmental data maintenance, city appearance and environmental thematic statistics, city appearance and environmental thematic map production, system management, and system monitoring. The functional structure of each module is shown in Figure 3.

(1) City appearance environment map browsing module. This module is mainly used to view the city appearance environment map, and perform some basic map operations, such as measuring distance, adding markers, and displaying the administrative area range. In addition, the city appearance environment information data stored in the database can also be viewed on the city appearance environment map of this module.
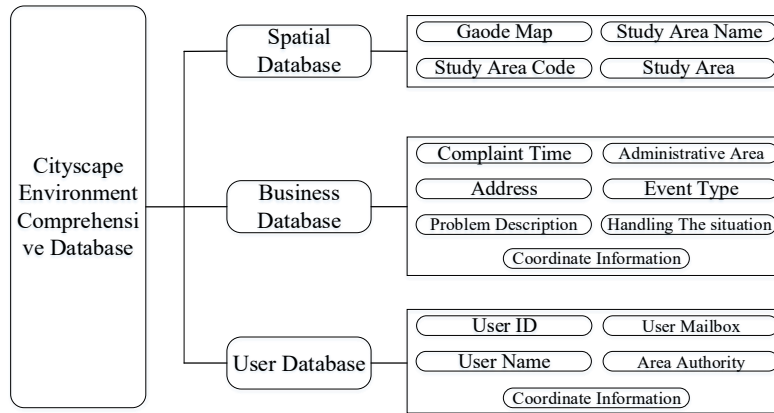
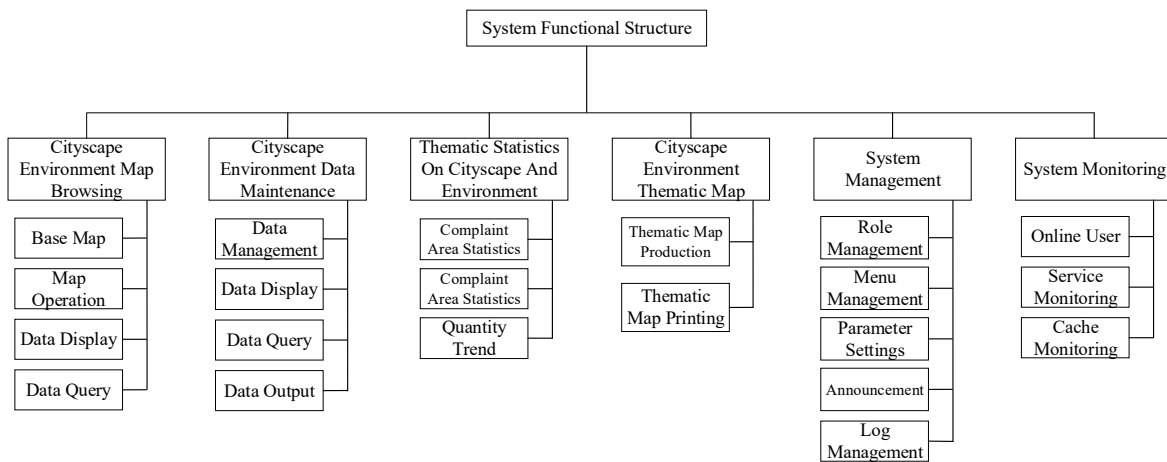**Figure 2. Data layer structure.**

Cityscape Environment Comprehensive Database
- Spatial Database: Gaode Map, Study Area Name, Study Area Code, Study Area
- Business Database: Complaint Time, Administrative Area, Address, Event Type, Problem Description, Handling The situation, Coordinate Information
- User Database: User ID, User Mailbox, User Name, Area Authority, Coordinate Information

Figure 2. Data layer structure.

System Functional Structure

- Cityscape Environment Map Browsing: Base Map, Map Operation, Data Display, Data Query
- Cityscape Environment Data Maintenance: Data Management, Data Display, Data Query, Data Output
- Thematic Statistics On Cityscape And Environment: Complaint Area Statistics, Complaint Area Statistics, Quantity Trend
- Cityscape Environment Thematic Map: Thematic Map Production, Thematic Map Printing
- System Management: Role Management, Menu Management, Parameter Settings, Announcement, Log Management
- System Monitoring: Online User, Service Monitoring, Cache Monitoring

Figure 3. System functional structure.

(2) City appearance environment data maintenance module. It is mainly used to dynamically manage the data of urban appearance and environment problems, and its main functions are data management and data location query[5]. Data management refers to adding, deleting, modifying and checking the data of urban appearance and environment problems in the business database; Data location query is to view the specific location of problem data on the city appearance environment map.

(3) Special statistics module of city appearance and environment. The special statistics module of city appearance and environment is mainly divided into three aspects of complaint area statistics, complaint type statistics and quantity change trend for query and statistics, which are displayed in the form of charts. The statistics of complaint type is to analyse the number of urban appearance and environmental problems in each administrative region within a certain period of time; The statistics of complaint types is to analyse the types of various urban appearance and environmental problems within a certain time range; The quantity change trend refers to the statistics of the number of urban appearance and environmental problems that have occurred in the last ten months. It shows the overall quantity change trend in the form of broken line chart in the unit of month.

(4) City appearance and environment thematic map module. According to the requirements of the city appearance and environment management, the city appearance and environment problems are rendered by the colour changes of the map or different symbols for one or several special indicators, so that the city appearance and environment problem data can be displayed in a more intuitive form and provide data support for the analysis of the city appearance and environment report.

(5) System management module. The main purpose of this module is to manage the system content, as well as to set user operation authority and assign roles according to the actual situation; Menu management is to manage the functional

modules of the system, and expand the modules according to the actual situation when necessary; Parameter settings is used to configure the parameters of login and initial interface; Notice announcement: you can publish announcements in the system, and all users can view them when logging in; Log management is used to view the operation and login logs of system users.

(6) System monitoring module. This module is mainly used to monitor the usage of users and services using the system. Online users are used to viewing users who are using the system; Service monitoring is used to view various information of the current server; Cache monitoring is used to monitor the size of the system's current cache Redis. The speed of fetching data from Redis is much faster than that from the database. Therefore, the hotspot data frequently used by the system is saved in Redis[6].

3. TECHNICAL FEATURES

3.1 Module division

This system adopts the MVVM model based on the SpringBoot microservice architecture[7]. The MVVM model can completely separate the view layer displayed to the user from the business logic layer of the back end[8]. The front end transmits data to the back end by sending Ajax requests, and the back end responds and returns the corresponding content after receiving the request, as shown in Figure 4.
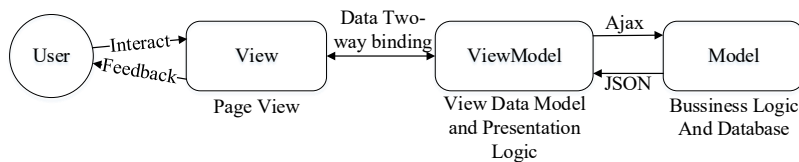

Figure 4. MVVM model.

3.2 Leaflet with ArcGIS API for JavaScript

The map visualization function of this system adopts the technology of Leaflet with ArcGIS API for JavaScript, which is an open-source JavaScript library for Web interactive maps and mobile devices. Because of its lightweight characteristics, it has good compatibility when loading various layers, and the speed of loading map data is very fast.

ArcGIS API for JavaScript will correspondingly convert the user's operation into HTTP request according to the format of the REST API provided by ArcGIS Server[9]. After receiving the request, ArcGIS Server will call the data for processing, and return the result to ArcGIS API for JavaScript in JSON format. Then ArcGIS API for JavaScript will analyse the result and display it visually through the API, and finally return it to the application program[10]. The specific operation flow is shown in Figure 5.

Although the ArcGIS API for JavaScript provides more comprehensive functions than Leaflet and can publish maps made in ArcMap to ArcGIS Server for calling, its own module is too large, resulting in a slow page loading speed[11]. ArcGIS API for JavaScript has supported importing modules through Npm since version 4.18, eliminating the operation of local deployment in the previous version to improve the map loading speed. However, the requirements for network speed is still very high. Because of its lightweight characteristics, Leaflet has greatly improved the speed of loading maps compared with ArcGIS API for JavaScript. According to the respective characteristics of these two JS libraries and the overall requirements of the system, they are used in the home page and the city appearance environment thematic map generation module respectively. Since the home page needs to load maps frequently, the Leaflet with afaster loading speed is selected, and the city appearance and environment thematic map generation module needs to call the Changchun administrative division map published in the ArcGIS Server. Therefore, ArcGIS API for JavaScript is used to load the basic base map of the city appearance environment and the administrative division map.

3.3 ECharts data visualization

ECharts is the most widely used JS charting library in the market[12]. It relies on the canvas class library zender to realize the visualization of chart data. ECharts can directly use various data formats without conversion, realize the front-end display of tens of millions of data, multi-dimensional data filtering, view scaling and other interactive operations, support

multiple rendering methods, and meet the needs of most users. The basic process of making statistical charts using ECharts is shown in Figure 6.
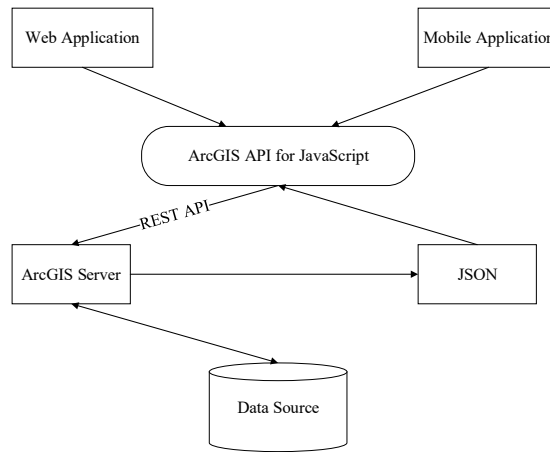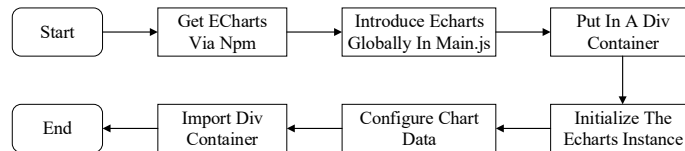

Figure 5. Workflow of ArcGIS API for JavaScript.

Figure 6. Basic flow of ECharts.

4. SYSTEM FUNCTION REALIZATION

4.1 Interface design

After the project is successfully started, you can successfully log in to the system by visiting the corresponding website and entering the correct account number, password and picture verification code, as shown in Figure 7.

Figure 7. System login interface.

The interface of the system is mainly divided into three parts, the function bar on the top, the navigation bar area on the left and the main content display area of the page, as shown in Figure 8.

4.2 System home

The content area of the homepage of this system is the road map of Gaode map, and the displayed area is the main urban area of Changchun City. The blue marked points on the map are the coordinate point of the city's appearance and environmental problem data stored in the database. Click the marked point to see the information data of the point in the pop-up box, as shown in Figure 9.
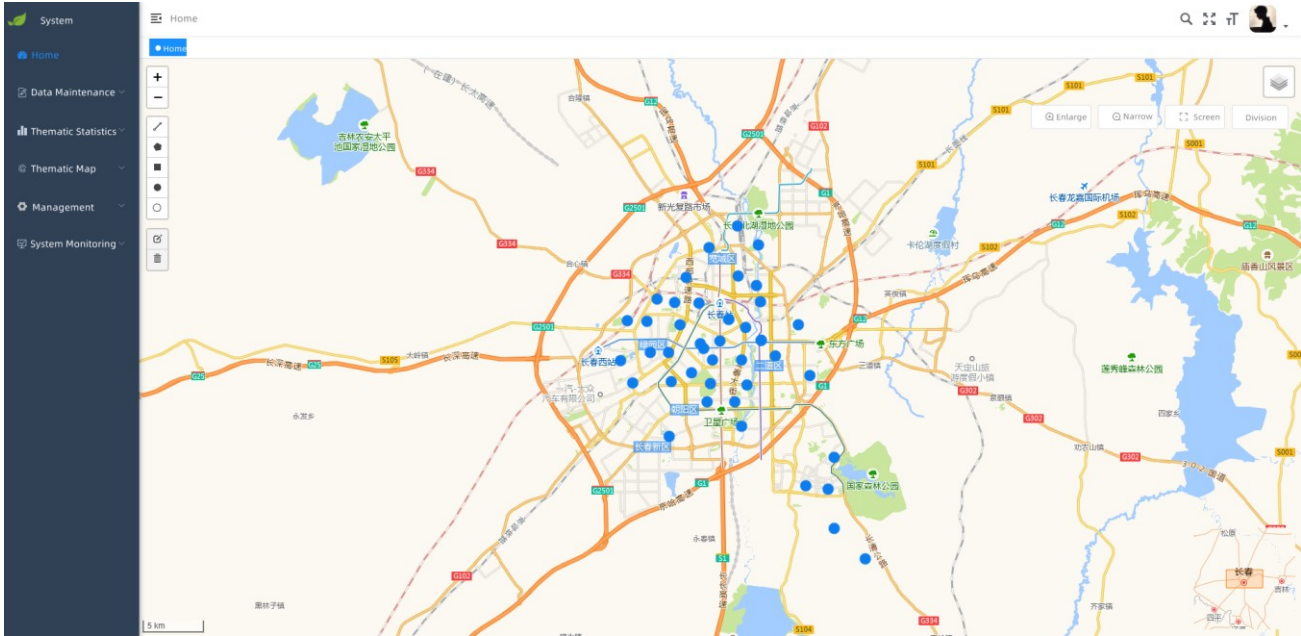
Figure 8. System main interface.

The two controls in the upper left corner of the map are respectively used to control the zoom of the map, drawing points, lines, and faces, and measure distance and range area. The layer control in the upper right corner of the map can control the switching between road map and satellite image. The four buttons below the layer control are used to enlarge the map, reduce the map, restore the map to its original position, and display the administrative division range.
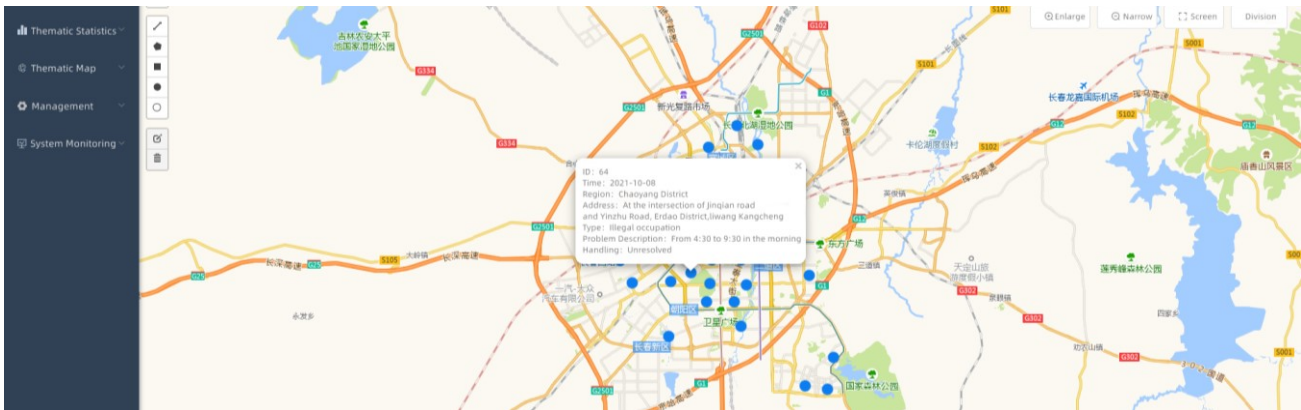

Figure 9. Data information display

4.3 Business data management module

The data management module under the maintenance of the city appearance and environmental data in the sidebar is mainly used to store the business data of the system, that is, the city appearance and environmental problem data. In this module, the city appearance and environmental problem data stored in the MySQL database is displayed in the form of a list.

At the top of the data list is the search area and the adding, modifying, deleting, and exporting buttons. After selecting the time range, event type and administrative area to be searched. Clicking search, the system will query the data that meets the search criteria and update the data list, as shown in Figure 10.

Figure 10. Data list of urban environment problems.

Through the adding button below, you can add new data of urban appearance and environment problems to the database. In the pop-up dialog box, fill in the corresponding contents. The latitude and longitude coordinate data cannot be entered by manually filling in the data. Instead, clicking the "get coordinates" button to obtain the longitude and latitude coordinates from the map, as shown in Figure 11.

Figure 11. Add cityscape environmental issues data window.

After clicking the getting coordinates from map button, the system will automatically jump to the home page. You can click the administrative region button in the upper right corner to display the administrative region range on the map, so that you can find the location you want to mark. After you find the location you want to mark by zooming the map, double-click the map to mark on the map.

After the mouse double clicks on other positions on the map, the previously marked point will be cancelled and remarked on the new position. After completing the relevant operations, click the return list button below the map to jump back to the data management interface. At the same time, the system will automatically fill in the latitude and longitude coordinates of the just marked points in the corresponding area. After completing the entry of basic information, the data can be added to the data list, after selecting the checkbox in front of the data to be deleted in the data list, click the delete button to quickly delete multiple data; the operation process of the export function is similar to that of delete. If you directly click the export button without selecting data, the system will prompt whether to delete the list Export all the data in the file, or select the data you want to export, click Export, and select the save location of the file to download.

There are three options under the operation tab of each data in the data list: edit, delete and location. To click Edit to see all the information about this piece of data onto the pop-up dialog box, and you can modify the data in real time on this

interface. If you want to modify the latitude and longitude coordinates, you also need to click to get the coordinates from the map, the system will jump to the home page and locate the view to the location of the point, and double click the position you want to modify to remark it. To click the positioning option, you can see the location of the point in the home page and highlight it, as shown in Figure 12.
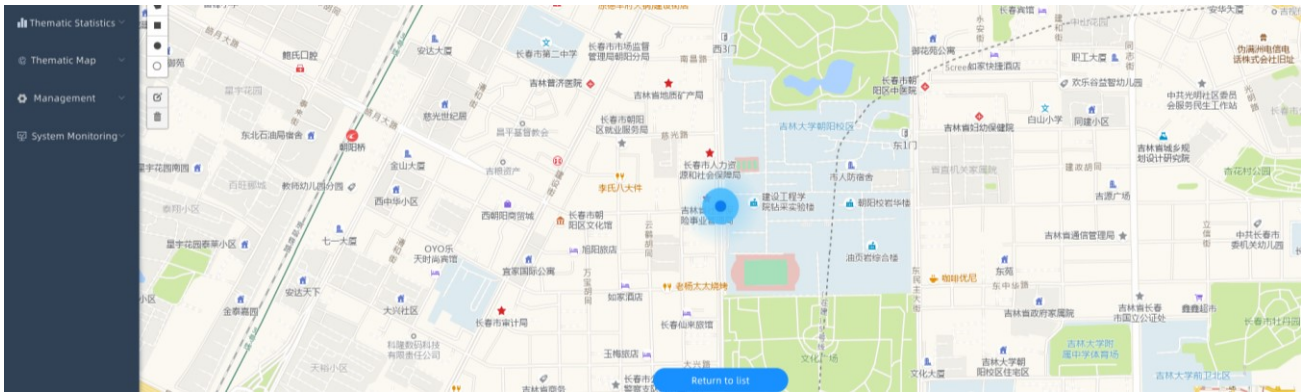

Figure 12. View the location of the point on the map through the positioning option.

4.4 Statistical analysis module

This module summarizes the data of city appearance and environmental issues. The content area is mainly divided into the query area and the chart area. The chart area is divided into three parts, as shown in Figure 13. The statistical analysis chart of administrative district complaints in the upper left corner is mainly used to count the number of urban appearance and environmental problems in each administrative district. The statistical analysis chart of complaint types in the upper right corner is mainly used to calculate the number of each type of city appearance and environmental problems, which is displayed in the form of a bar chart. The trend graph of the number of city appearances and environmental problems below is used to count the number of city appearances and environmental problems in the past ten months. In the query area above the chart area, select the administrative area and date range, and click search. The system will query the data that meets the requirements, and the chart below will also change according to the data.
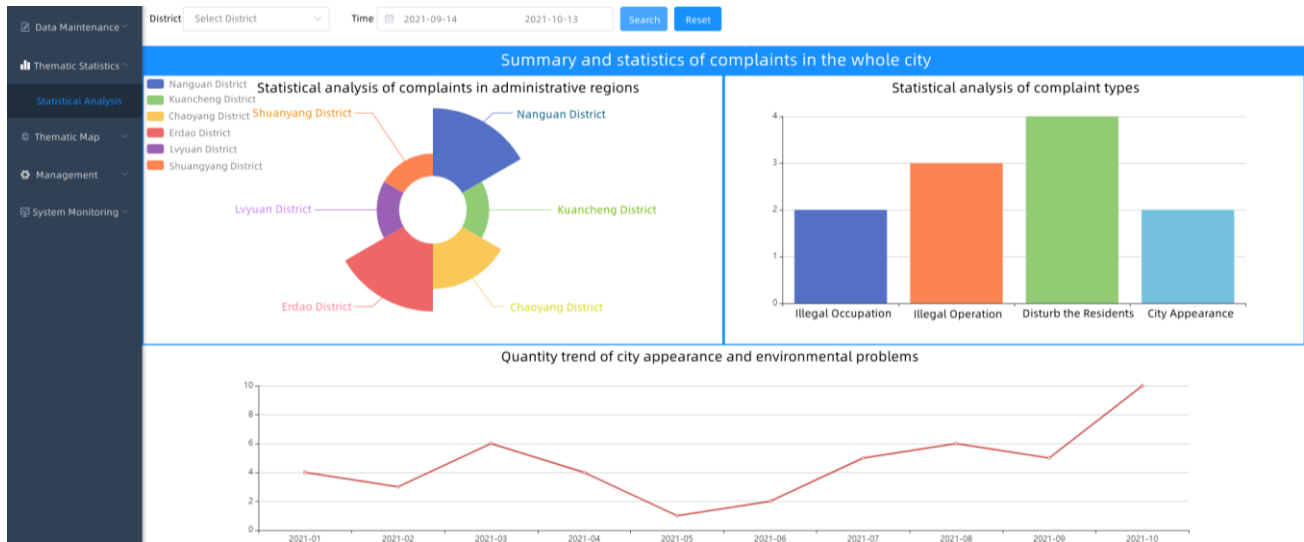

Figure 13. View the results after selecting the date range you want to query.

4.5 Thematic map production and output model

The content area of this module is the road map of Gaode map and the administrative division map of the main urban area of Changchun City. The road map of Gaode map is loaded through the custom TileLayer provided by ArcGIS API for JavaScript. The administrative division map of the main urban area of Changchun is processed and rendered in ArcMap and imported from the spatial database. After that, it is published as FeatureLayer by ArcGIS Server. The published layer is called in the code and superimposed on the basic base map.

To click the generate thematic map button in the lower left corner. In the generate thematic map interface popped up in the upper left corner of the map, select the date and event type, and then click generate thematic map. According to the selected restriction conditions, the system will assign the corresponding value of the corresponding field of the layer in the spatial data base after classification and statistics by administrative region and render it, as shown in Figure 14.
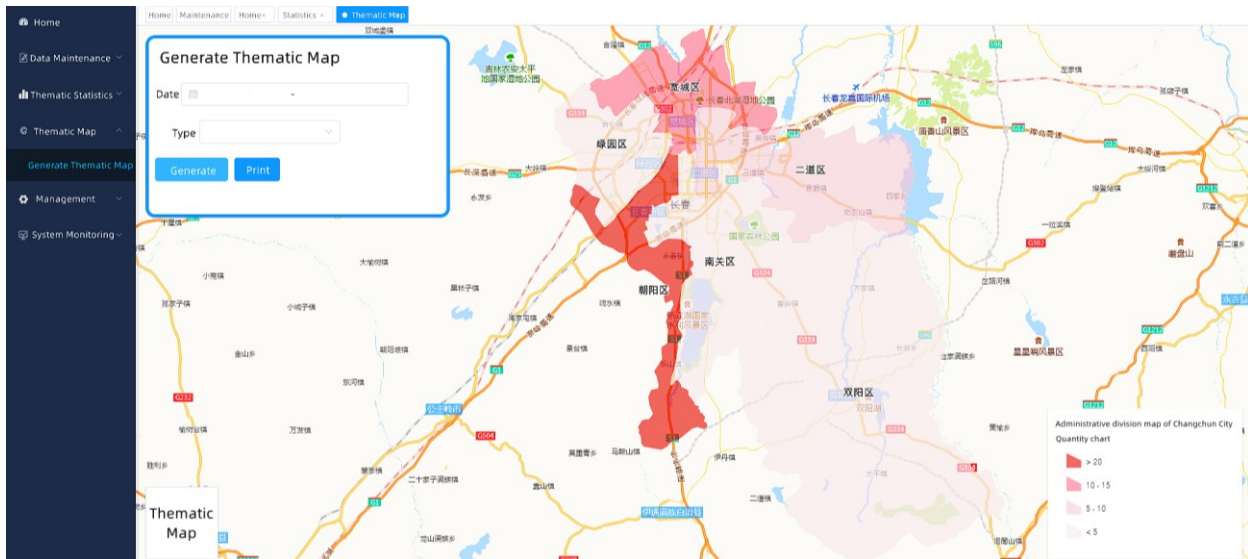

Figure 14. Setting user permissions.

To click the print button and the export interface pops up in the upper right corner. After selecting the file format and setting the height and width, enter the file name and click export to print the thematic map, as shown in Figure 15.
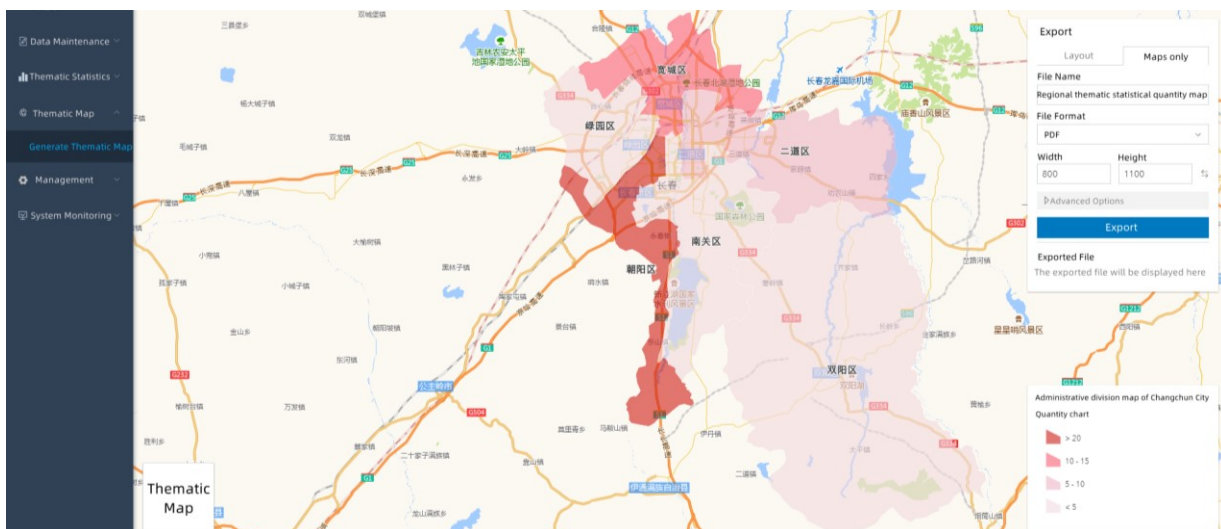

Figure 15. Set the thematic map export style.

4.6 System management

The system management module can configure and manage the system in real-time according to the needs, and set the use rights that only for administrators. The display and hiding of each module in the system can be configured through menu management.

5. EPILOGUE

In this paper, a city appearance and environment management system based on WebGIS is implemented by combining various open source frameworks. The system has the advantages of "unified data access, unified authority management, and unified log management", which provides convenience for data access and acquisition, meets the actual needs of users, and further improves the efficiency of urban management.

This paper combines spatial data with business data and designs different functions for each functional department of the Urban Management Bureau. It has practical value in data query, statistical analysis, thematic map production, data visual display and so on. By using this system, the urban management bureau can quickly and accurately grasp the exact location and specific information of the urban appearance and environmental problems, effectively improve the efficiency of the staff, and achieve the effect of improving the level of urban governance.

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