

Design and Implementation of Open-Source WebGIS System for Orchard Land Management

Lei Cui, Weidong Li*, Xiangye Wang, Xiaofei Niu

College of Information Engineering, Henan University of Technology, Zhengzhou, 450001, China

**Corresponding author*

Keywords: GeoServer, PostgreSQL, Orchard land management system

Abstract: For the problem of the long development cycle and high cost of orchard land management platform, and lack of integration with geographic information, the paper is based on open source GIS service platform GeoServer, open-source spatial database PostgreSQL, open-source front-end framework Vue, services related to OGC (WFS service, WMS service, Etc.), combined with Web GIS client Openlayers JavaScript class library package, designed and developed a set of open source WebGIS orchard land management system. The system platform mainly realizes the geographic information management of orchard land and essential functions such as order management, evaluation management, fruit sales, and user information management.

1. Introduction

As the "Internet +" strategy is put forward, many industries with the characteristic of "technology" on the Internet clippers have developed rapidly. However, the development of agricultural products, fruit sales, and orchard land management platform construction is not satisfactory compared with foreign countries. Most of the platforms have only developed essential sales functions [1,2], although they can satisfy the basic needs of users, but can not meet the needs of producers, such as land geographic information management. In addition, although GIS has been developing rapidly in recent years, there are still relatively few agricultural fruit sales and land management combined with GIS technology, and there are few links with spatial information. In this aspect, more exploration is needed.

Domestic agricultural fruit sales and land management platforms do not have many combinations with GIS services, the only combination is in logistics services, but there are no relevant functions in land cadastral information management and land monitoring. Although these platforms are perfect, the tightness with geospatial information is not intense. In addition, in the platform development mode, most of the platforms in China's land management are developed by enterprises based on native technology. Although the system developed in this way has good performance, all the technologies need to be developed by self-exploration, which results in this development model having a long cycle and high cost [3]. As for the orchard land management system model based on an open-source platform and GIS technology, there are still few in China [4]. Due to the early development of information technology and mature technology in foreign

developed countries, foreign orchard land management platforms are developed earlier, have better functions, and do better in integrating with GIS services, such as expert consultation in orchards, fruit monitoring, fruit harvesting, and other functions [5-8].

The system is based on the open-source GIS service platform GeoServer, open-source spatial database PostgreSQL, open-source front-end framework Vue, OGC related services (WFS service, WMS service, Etc.). It is designed and implemented with the Openlayers JavaScript library package of Web GIS client [9-12], mainly to achieve the orchard land geographic information management and order management, evaluation management, fruit sales, user information management, and other essential functions.

2. The Overall Framework Design of the System

2.1. Overall System Design Scheme

The whole WebGIS system is divided into four layers, as shown in Figure 1. The database, GIS server, Web server, and client are in order.

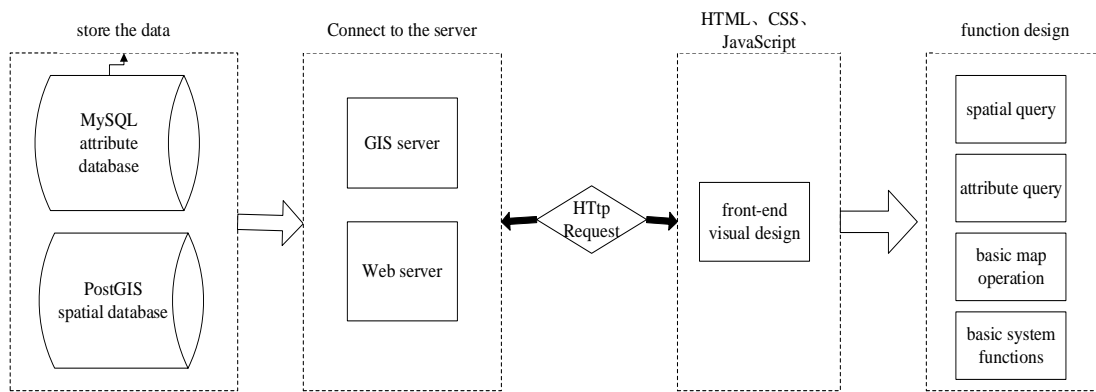


Figure 1: Overall design plan of WebGIS system.

As can be seen from the figure, the primary process of establishing the system is as follows:

- The user sends HTTP requests to the Web server through the Web page.
- The Web server receives HTTP requests from users and sends the requests for geographic services to the GIS server.
 - After receiving the requests, the GIS server parses them, extracts the relevant geographic data from the spatial database, and returns it to the Web server.
 - After receiving the data transmitted from the GIS server, the Web server encapsulates it into a Web page or JSON object and returns it to the client, and then the browser displays it on the front-end.

2.2. System Client Design

The client of this system is built using the popular front-end framework Vue and uses Openlayers technology to construct it. Users directly interact with the client in a system based on the Browser/Server (B/S) architecture. Therefore, the ease of use of the user interface is significant. Vue projects can be easily built-in WebStorm by simply downloading the Vue-CLI scaffold, through which Vue projects can be built quickly. Through Npm Install, users can install the various packages needed, such as Ol, Element-plus, Etc. After that, users can modify the route and add the path to run it properly.

Through Openlayers, vector and satellite image maps of Tianditu can be introduced in the Vue

framework, and some interactive functions can be added, such as essential roaming, zooming in, and zooming out. The Xinjiang parcel data is imported into the PostgreSQL database, and the front-end page requests the data through AJAX technology and displays it in JSON format on the front-end.

Use Openlayers technology to load parcel data, query GeoServer published parcel data based on GeoServer's workspace URL and layer name, and visualize it in the front-end interface via Openlayers. Query different parcels by entering workspace URL and layer name.

2.3. Design of System Server

The system's GIS server uses GeoServer, and the Web server uses Tomcat. By integrating GeoServer with Tomcat for the Web server, we do not need to rename it. GeoServer is a more mature open-source map service publishing platform that can easily publish WCS, WFS, WMS, and other map services. After downloading the GeoServer zip file from the official website, unzip it and open the Bin directory, double-click "Start.up" to run it directly, and the GIS server will start.

Enter the GeoServer management page, enter the account and password to log in, create a new workspace, and enter the workspace name and namespace URL.

Then create a new data source, and add data storage. Since the data has been imported into the PostgreSQL database through PostGIS earlier, the system selects the "PostGIS - PostGIS Database method to add data."

Finally, the required layers in the database are published, and after the map service is published, the map service can be invoked in the front-end framework Vue by using Openlayers with the space name and namespace URL and can be displayed visually in the front-end.

2.4. Design of the Conceptual Structure of the Database

The system uses PostgreSQL to store spatial data and MySQL to store attribute data, which are excellent relational databases where data can be stored efficiently. E-R diagram, also known as the entity-connection diagram, is divided into three parts: entity, attribute, and relationship, and is an effective method for describing real-world conceptual models. The E-R diagram of the system is shown in Figure 2 below.

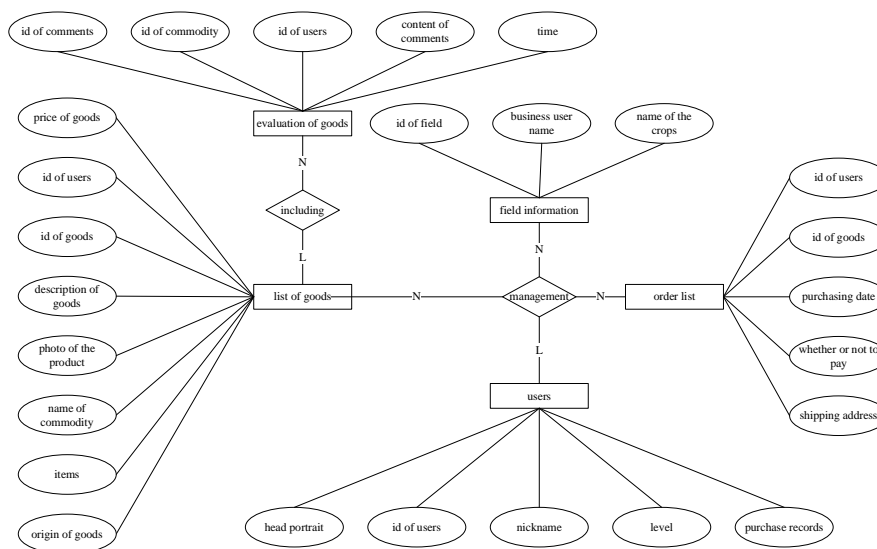


Figure 2: E-R diagram of the system.

2.5. Design of the Structure of the Database Tables

The data to be stored in this system are spatial and attribute data, and it is necessary to design spatial and attribute data tables. The difference is whether there is a Geom field to store the spatial coordinate information (Table 1).

Table 1: Farmland Datasheet.

field names	type	meaning
gid	Int	(primary key)id of field
entity	Varchar	users
Geom	Type	coordinate information
landowner	Varchar	field owners
layeruse	Varchar	crops

For standard property tables, a unique primary key is set for each table to increase the speed of data manipulation while also considering the relationships between the tables. The required columns in the table need foreign keys to ensure data consistency. Here is the example of the user table (Table 2) and fruit product list (Table 3).

(i) user (user table): store information of the user.

Table 2: User Table.

field names	type	meaning
id	Int	(primary key)id of users
name	Varchar	user's nickname
Password	Varchar	user's password
Img	Varchar	user's head portrait
recordt	Varchar	purchase records
home	varchar	shipping address

(ii) shop (fruit product list): store information about fruits.

Table 3: Commodity Table.

field names	type	meaning
id	Int	id of goods
Type	Varchar	commodity type
Name	Varchar	name of commodity
Price	Int	price of goods
Imgpath	Varchar	photo of the product
Detail	Varchar	product details
Producplace	Varchar	product origin information

2.6. Design of System Data Storage

The system imports Shp data into the database through the PostGIS plug-in that comes with PostgreSQL, and finally, the map service is published through GeoServer.

3. Design of System Functional Modules

3.1. User Login Module

User login: Users enter their account and password to the system home page. If it is the first time entering the system, the user needs to register the account and password before the user can enter. If the user forgets the account password, the user needs to retrieve the password operation.

3.2. Fruit Sales Module

Fruit sales: The browser interface displays the list of goods, and users select the appropriate fruit according to their own commodity needs while supporting purchasing goods, commodity comments, and commodity information view function.

Order-management: Users purchase goods to generate orders, the back-stage records the purchase records to carry out the corresponding order-management, and when the user confirms receipt, order management ends.

3.3. User Evaluation Management Module

User evaluation management: Enter the product purchase page, pull down the product review area, and users can view the comments given by other users. They are also able to publish their comments.

3.4. User Information Management Module

User information management: Users can modify nicknames and head portraits in the personal center and view their orders, consumption records, and other information.

4. Example of System Application

4.1. System Interface

The initialization interface of the Vue framework to integrate Openlayers is shown in Figure 3.



Figure 3: The main interface of the system.

The system's main interface is mainly divided into three parts: Some essential functions on the right side. The whole interface is the function display area of the system. The system initialization interface shows the image map of heaven and earth. A toolbar on the top right of the system holds some essential functions, such as drawing points, drawing lines, adding fields, clearing layers, Etc.

4.2. Loading Parcel Data

The orchard land plot vector data used in the orchard land management platform came from the Dwg format file drawn by the survey, which could not be displayed and edited visually by the Openlayers API after the Shp data was converted by Arcgis and published by Geoserver. The problem is solved by converting the Dwg file to the Dxf file by AutoCAD and then to the Shp file by TransCAD, where the coordinate system used in the original Dwg file is CGCS2000 coordinate system. The coordinate system of the Shp file converted by TransCAD is the WGS84 coordinate system, then use Arcgis to define the projection coordinate system as a Lambertian projection to get the Shp file we need, and then we use the coordinate alignment to realize the geometric correction and publish the data.

Integrating the Vue framework and Openlayers, the parcel data is loaded using the New WFS.WriteGetFeature class and displayed through the New Map class, which can be continuously extended for various applications through calls between components.

4.3. Query Information Function

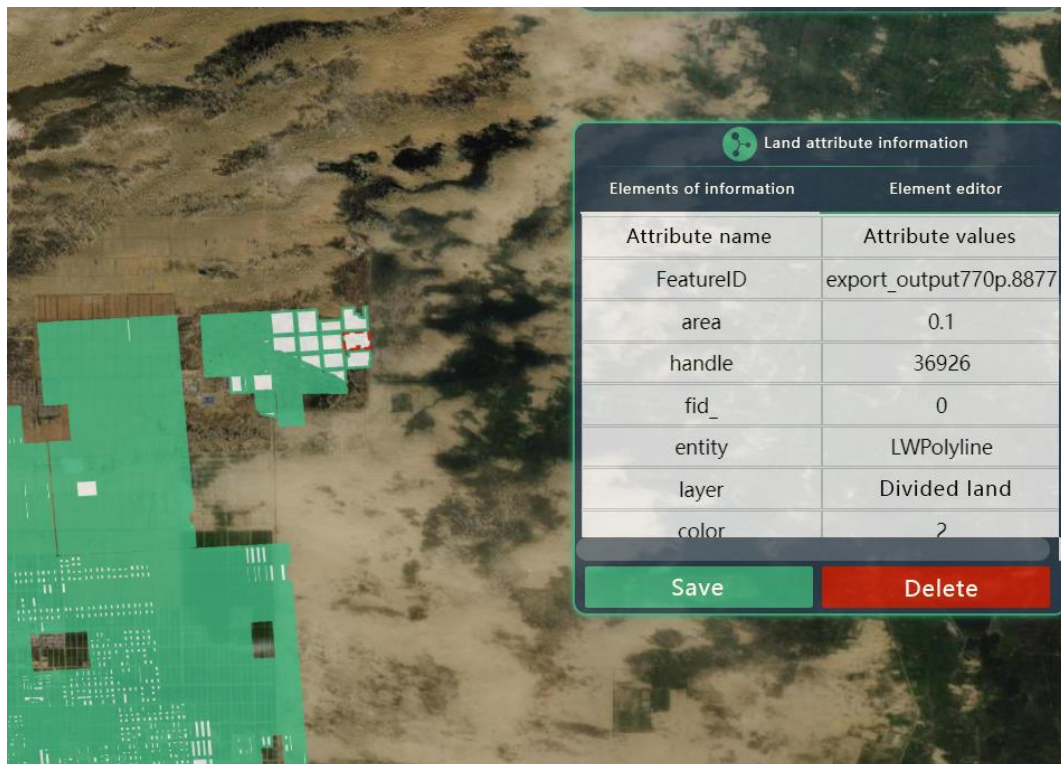


Figure 4: Search results for attribute information.

Because of massive geographic data characteristics, developers always consider the user's boredom of browsing massive data when designing a WebGIS system. When viewing parcels, people always want to view the parcel data of a particular feature and do not want to see the dense parcels. Therefore, a filtering condition can be added when using Openlayers to invoke parcel data

and make the front-end display only the parcel data that the user is looking for so that users do not have to worry about browsing massive data.

When the orchard land information is loaded, when we click on the parcel, the parcel will be highlighted, and the parcel property information box will pop up. In the box, in the column of element information, we can see the basic information such as the area and coordinates of the parcel. In the column of element editing, we can see the fundamental property value of the land by clicking on the parcel to query the basic land information is divided into two steps. Firstly, Click the ClickFeature event to select the parcel and highlights the parcel in a specific form. Then, the GetFeatureInfoUrl event obtains the layer property data and passes it to the front-end in JSON format for visual display in the form of a table so that the user can intuitively see the basic property information of the selected land. The query interface is shown in Figure 4.

4.4. Modify Information Function

4.4.1. Orchard Land Information Modification Function

When we select a parcel of land, a parcel property information box will pop up, in which we can edit the parcel, such as decomposition, coloring, modifying properties, Etc., and save the modified content. The whole process can be divided into three steps. First, the parcel property information is queried and displayed visually through the ClickFeature and GetFeatureInfoUrl functions. Then, the property information is modified by WFSTSerializer. WriteTransaction. Finally, the edited data is sent to the GIS server GeoServer in XML format, and the GeoServer receives the data, and then the front-end callback function refreshes the page.

4.4.2. Delete Orchard Land Information Function

Based on querying orchard land information, the selected parcel data can be deleted by the DeleteFeature button. Its process can be divided into two steps. Firstly, the parcel property information is queried and displayed visually through ClickFeature and GetFeatureInfoUrl functions. The second is to call the WFS service, change the type in the request body to DelFeatures, and refresh the page when the land data is deleted successfully.

4.4.3. Add Orchard Land Information Function

Click the "Draw Polygon" button in the upper right toolbar to add orchard land, which can be divided into three steps. First, the land is drawn by the DrawInteraction function. Then, the drawing ends when the beginning and end of the polygon coincide. Finally, click on the drawn polygon to bring up the plot property information box and add basic property information to the land. After that, it needs to be saved in JSON format through GeoServer's WFS request.

4.5. Buy and Sell Fruit Function

Fruit trading in this system no longer appears as a regular commodity list. However, combined with GIS and agricultural products, through the WMS service of Openlayers to load data, the plot is displayed visually in the browser, and the user clicks on the plot to bring up a pop-up box with the picture and description of the product and clicks on the buy button below to enter the product transaction page to trade the product.

4.6. Back-Stage Management Function

4.6.1. Personal Center Management Function

In the personal center interface, users can view their purchase records, manage their orders, and modify personal nicknames and head portraits.

4.6.2. User's Evaluation Management Function

Create a comment section below the product transaction for users to comment and discuss. Other users can view the comments, decide whether to buy and post their comments after the purchase.

5. Conclusions

This paper profoundly explores the integration of GIS service and orchard land management system and develops a GeoServer-based orchard land management system with the support of open-source technology. The main work accomplished in this project are: data processing, publishing geographic data through GeoServer, using front-end framework Vue, orchard land geographic information management functions, and the essential functions of the fruit selling platform.

The system has achieved some essential GIS functions and some basic platform functions, but there are also many shortcomings, which need to continue improving to realize the farmland's modernization.

- (i) The system accesses the real-time farmland monitoring function.
- (ii) System access to experience exchange and knowledge base function.
- (iii) Further improve the farmland geographic information management module to realize the functions of intelligent matching plots by the user uploading pictures.

Acknowledgements

The authors express gratitude to the Innovation and entrepreneurship training program for College Students (NO.202210463018 and NO.202210463020).

References

- [1] Junlan Jin, & Wei Xiong. (2019). *Problems and Research of Agricultural Products Sales Platform Service. Investment Guide for the Public*, 2, 280-281. (in chinese)
- [2] Jia-ning Liu, & Yumin Wei. (2020). *Analysis of Agricultural Products Supply and Internet Platform Sales. Modern Marketing*, 2, 69. (in chinese)
- [3] Tao Huang. (2022). *Research on Tool-Based Static Detection of Mobile Application Code Defects. Journal of Wuhan Engineering Institute*, 34(01), 22-26. (in chinese with English abstract)
- [4] Wei Tang. (2013). *The Information System of the Price of Agricultural Products Base on WebGIS (Master's thesis, Sichuan Normal University)*. (in chinese with English abstract)
- [5] dos Santos, U. J. L., Pessin, G., da Costa, C. A., & da Rosa Righi, R. (2019). *AgriPrediction: A proactive internet of things model to anticipate problems and improve production in agricultural crops. Computers and electronics in agriculture*, 161, 202-213. DOI:10.1016/j.compag. 2018.10.010.
- [6] Alzarliani, W. D., Arsyad, M., Salam, M., Pulubuhu, D. A. T., & Unde, A. A. (2019, February). *Effect of App utilization on the agricultural efficiency of rural communities. In IOP Conference Series: Earth and Environmental Science (Vol. 235, No. 1, p. 012101)*. IOP Publishing. DOI: 10.1088/1755-1315/235/1/012101.
- [7] Cotter, M., Asch, F., Abera, B. B., Andre Chuma, B., Senthilkumar, K., Rajaona, A. & Stuerz, S. (2020). *Creating the data basis to adapt agricultural decision support tools to new environments, land management and climate change—A case study of the RiceAdvice App. Journal of Agronomy and Crop Science*, 206(4), 423-432. DOI: 10.1111/jac.12421.
- [8] Dai, Y., Duan, Z., & Ai, D. (2020, August). *Construction and application of field investigation support platform for*

land spatial planning based on GeoServer. In *Journal of Physics: Conference Series* (Vol. 1621, No. 1, p. 012059). IOP Publishing. DOI: 10.1088/1742-6596/1621/1/012059.

[9] Honecker, A., Schumann, H., Becirevic, D., Klingbeil, L., Volland, K., Forberig, S., & León, J. (2020). Plant, space and time-linked together in an integrative and scalable data management system for phenomic approaches in agronomic field trials. *Plant methods*, 16(1), 1-13. DOI: 10.1186/s13007-020-00596-3.

[10] Weisong, M., Shaoqi, G., Stankovski, S., Xuejie, Z., Kanianska, R., & Jianying, F. (2019). Web GIS-based suitability evaluation system for Chinese table grape production. *Computers and Electronics in Agriculture*, 165, 104945. DOI: 10.1016/j.compag.2019.104945.

[11] Tian Tian and Haibin Chang. (2019). Marine Information Sharing and Publishing System: A Web GIS Approach. *Journal of Coastal Research*, 94(sp1), pp. 169-172. DOI: 10.2112/SI94-035.1.

[12] Zhang, B., Ye, Y. W., Shen, X. Z., Mei, G., & Wang, H. X. (2018). Design and implementation of levee project information management system based on Web GIS. *Royal Society open science*, 5(7), 180625. DOI: 10.1098/rsos.180625.