

The soil nutrient monitoring system

Di Zu^{1,2,3}, Xiaodong Yang^{2,3}, Zhongbin Su^{1*}, Xiaohe Gu^{2,3}, Yancang Wang^{2,3,4}

- 1.School of Electronic Engineering and Information Northeast Agricultural University. Harbin, 150030, China
E-mail: suzb001@163.com
- 2.Beijing Research Center for Information Technology in Agriculture. Beijing, 100097, China
- 3.National Engineering Research Center for Information Technology in Agriculture. Beijing, 100097, China
- 4.Hebei Collaborative Innovation Center for Aerospace Remote Sensing Information Processing and Application
Langfang. 065000, China

Abstract: Soil nutrient monitoring system is to master the nutrient status of the bare ground, and quickly extract the information of farmland nutrient. Because of having a significant impact on the crop, the soil nutrient monitoring is important. For the lack of monitoring soil nutrient monitoring currently, combined with “3S” technology, spatial database technology, computer network technology and modern agricultural information technology as the basis, using WebGIS Service standard spatial database engine, the soil nutrient monitoring system based on soil nutrient information of Yangling was scientifically constructed. It achieved soil nutrient management from the large-scale, made the monitoring process towards standardization, improved management efficiency and scientific level, and provided technical support for farmland quality decisions.

Keywords: Soil nutrient; 3S; Monitoring system;

1. Introduction

Soil is the major means of production in agriculture, and one of the material basis of human survival. Soil nutrient is the main manure for plant growth, having a close relation with agricultural production. Therefore, finding out the dynamic changes of soil fertility and understanding the soil nutrient status become particularly important [1-3].

Traditional soil nutrient monitoring is sampling methods, that is, the sample unit under certain guarantee reliability was analyzed and processed [4]. Compared with traditional methods of soil nutrients experimental analysis, remote sensing technology is fast, non-

destructive and largely obtain characteristic feature information. Hyperspectral remote sensing technology can get very narrow and continuous spectral data, and the spectral distribution of the soil can be obtained in real time. Multi-spectral sensors with high spatial resolution in the analysis of spatial patterns of soil nutrients with greater advantage. However, the data about the time, region, types and other important information was obtained by remote sensing instruments, just left by the way written monitoring reports, which was not conducive to research and reference for successor. So it is necessary to build a monitoring system on soil nutrient.

But there were more monitoring systems and warning systems designed on the quality of farmland dynamic changes. Land nutrient management put still emphasis up on regional management and infrastructure management, but dynamic monitoring and management lag behind, and there was also no single, large, fast and timely the system designed for farmland nutrient. Therefore, it is necessary to build a dynamic and real-time monitoring management system for soil nutrients, in order to timely and accurately grasp the changes of soil nutrients, to provide better decision support for the realization of national soil science management [5-7].

This article used the structural combine Browser/Server mode and Client/Server mode to develop soil nutrient monitoring system based on “3S” technology. The soil nutrient information was achieved by using the way RS and GPS and combined with the GIS functions, such as data analysis and processing, storage, management and distribution, to realize information support for soil nutrients. The system could monitor soil nutrients better and more accurate, which could realize the remote management for soil nutrient and provide intuitive, efficient and accurate information for users. What’s more, it has scientific management decision support for the soil fast and largely [8].

2. System Design

2.1 System Architecture Design

Soil nutrient monitoring system was mainly service for agriculture-related research institutions and county, province and the country's agricultural management departments. The diversification of the service object required that the system must simple, friendly and easy to operate. The main structure of soil nutrient monitoring system had a C/S version and a B/S version. The system architecture is designed as a three-layer structure of the Web application, as shown in figure 1.

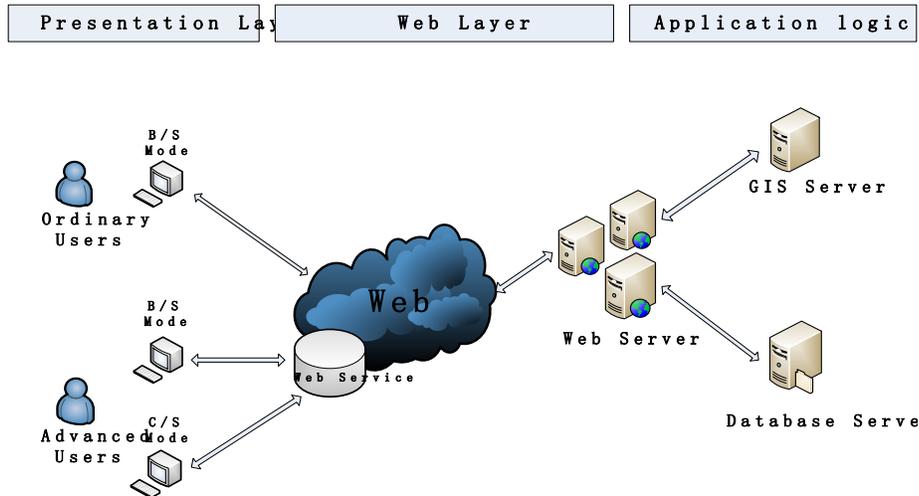


Fig. 1. Framework map of soil nutrient monitoring system

Client layer was the browsing, business applications and processing interface, including the end-users and the system administrator. The browser using B/S mode, is mainly applied to general users, which was designed to support the popular Internet Explorer 7.0 or higher, Firefox and Chrome and other common browsers. Manage client through combining C/S mode with B/S mode, was mainly for system administrators and advanced users.

Web tier was deployed on the Microsoft Internet Information Server (IIS). Web application server received a request from the client layer, which would be sent to the server, through the logic layer to be processing, responding and returning to the client.

The application layer logically consisted of GIS servers and database servers. GIS servers and database servers were used to manage GIS data services and other data services, respectively. Then they responded to requests and sent results to the Web layer, and further sent to the client. The client achieved direct access to a service request through the Internet. The ESRI company's ArcGIS products and Microsoft SQL server were used as GIS servers and database servers, respectively.

2.2 System Database Design

The system database included spatial database, attribute database, model database and text database. The spatial database used the way combine ArcSDE with SQL Server to manage and store. Attribute database, the model database and text databases directly used SQL Server for storage. The spatial database stored all kinds of raster data, including metadata, regional vector data, satellite remote sensing data and various image data

appearing in the processing. The property database included the information from GPS monitoring and sampling point and soil testing data. The model database included the experienced model equations from various regions or different years by the different methods, and the model customized by advanced users. The text database included soil nutrients thematic maps, monitoring reports, user information, and other documentation data.

3. System Implementation

3.1 Data sources and preprocessing

The system data included remote sensing data and ground monitoring stations data. For instance, Yangling Demonstration Zone in Shanxi Province SOM data in 2013 was obtained and handled. First, soil samples were collected by the way of five point mixing arable, which the sampling depth was 0-20cm. Then the samples were placed in the laboratory, dried, grinded and sieved (60 mesh) [9]. Soil organic matter was tested by the potassium dichromate volumetric method, which was described in Table1:

Table 1. Statistical description of soil organic matter content

Statistics	Quantity	Max	Min	Average	SD	Variance
Organic Matter (%)	(30 个)	3.19	1.29	1.85	0.42	0.17

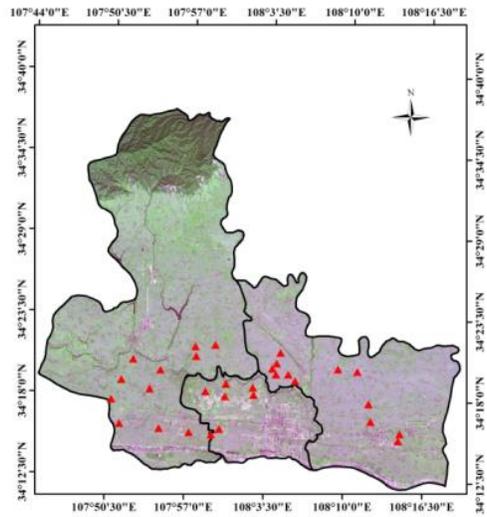


Fig. 2. The Spatial distribution map of soil samples

Second, the remote sensing image came from “Earth Observation and Digital Earth Science Center of Chinese Academy of Sciences - Earth Observation Data Sharing Program” to download the LandSat8 data on October 6, 2013, as shown in figure 3. The data sources are GEOTIFF format and Level 1 products.

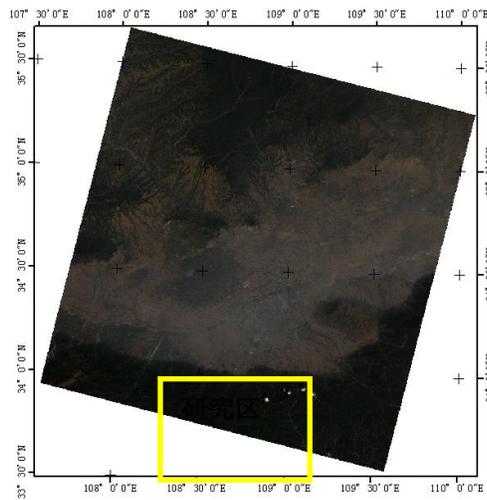


Fig. 3. The LandSat8 image in Shanxi Yangling demonstration zone

Remote sensing image preprocessing is the premise and basis of quantitative inversion of surface parameters. General remote sensing image preprocessing includes radiometric and geometric correction, and radiometric correction can be divided into radiometric calibration and atmospheric correction. This study mainly used the ENVI 5.0 software platform to process remote sensing data.

3.2 System Development Environment

System servers used the Windows Server 2003 SP2 operating system, built .NET Framework platform, installed and configured ArcSED, SQL Server databases and ArcGIS Server. Ordinary users did not need to install any client software, just through the browser. Advanced users through the browser and exe executable file maintain the system.

Microsoft Visual Studio 2008 was used in the system development platform, Microsoft SQL Server 2008 was applied in the database system and three-tier model of ArcSDE was applied in the spatial data engine. Meanwhile, Asp.NET solutions and C # language were used in the Server, the way combine C # with JavaScript scripting language was put into use to develop in the client. Server-side and client-side debugging were conducted under Visual Studio.NET environment.

4 Conclusion

With “3S” technology, spatial database technology, computer network technology and modern agricultural information technology as the basis, the system took the soil as the research object. It used WebGIS Service standard spatial database engine to build the soil nutrient monitoring system. Then it initially realized scientific and information management on the soil nutrients monitoring business, and further improved the level of the management and decision-making [10].

By using the data in Yangling, the system was tested and analyzed. The results showed that the design idea and architecture of system initially met the needs of precision agriculture, helped to make farmland data analysis, and made management become normalized and digitized [11]. Meanwhile, the system had the following characteristics.

- 1) The structure of system was designed combine B/S with C/S. The system did not install the application in the client, gave full consideration for people accustomed to the operation interface design, and used unified interface style and simple operation.
- 2) This system fully considered the actual situation of national soil nutrients, used custom monitoring model and hierarchical way to make business analysis based on satellite images and ground data at different times in different regions, and built thematic maps and monitoring reports for a specific analysis of the problem. It increased

application and scalability of the system to achieve practical results and dynamic monitoring of farmland nutrients.

3) The system combined RS technology with GPS technology and mixed satellite remote sensing image and data from actual measurement. The nutrient status of the arable land was monitored and the monitoring's precision and accuracy were improved. Then the system of data acquisition and monitoring functions were strengthened, at the same time, national and local farmland nutrient management level were also strengthened. It would be China's existing essential supplement and perfect part of monitor farmland.

This soil nutrient monitoring system is only a basic system. Its technical principles have some versatility, which can be applied to other information monitoring systems. On the one hand, this system will be added other farmland monitoring project, such as arable farmland productivity assessments system and environmental and health quality assessment system, to further expand the depth and breadth of the system. On the other hand, due to the continuity of arable data collection, the system will add the types of clients [12-13] and introduce portable terminals to combine the Internet technology with sensor technology. It will achieve scientific management of soil information collection, storage capabilities, and continuously improve the timeliness and usefulness of the system [14].

References

1. Hongna Yan, The status and evaluation of arable land in Pingdingshan City. 18,18 (2012)
2. Qiongzhe Wu, The farmland nutrient status and utilization in Hainan province. 27, 6 (2008)
3. Maohua Chen, Li Xiao, Wei Huang, Guangming Xue, The Analysis of farmland nutrient status in Fuyang City.35, 4 (2010)
4. Yinghe Shu, Tengbing He, Xue Gao, Pingying Zhao, Mujun Pan, Mingguo Zhao, Enxue Zhao, The comprehensive evaluation of soil nutrients of cultivated land in mountainous county – Karst.37, 8 (2009)
5. Houhai Liu, Zengqiang Hu, Jinhao Zhou, Feixiang Chen, The farmland quality dynamic monitoring system in Guangdong Province.40, 35(2013)
6. Qin Zhang, Wenjiang Huang, Tongyu Xu, Xiaodong Yang, Peng Sun, Wheat growth of the seedlings remote monitoring and diagnosis system.27, 12(2011)
7. Jinbao Yang, Baoling Hu, Jihong Ma, The research on soil nutrients and soil conditions. (1995)
8. Haiyang Yu, Yanmei Liu, Yansheng Dong, Xiaodong Yang, Dong Ren, Qiang Guan, Crop growth of the seedlings monitoring system based on spatial information.34,2(2013)
9. Kerry R, Oliver M A, Frogbrook Z L, Sampling in Precision agriculture.(2010)
10. Longbo Wang, Agricultural Aid Decision Support System Based WebGIS Service.13, 8(2007)
11. Wushi Guo, Xin Yi, Yunping Chen, Xiu Wang, The soil spatial information management system based on WebGIS and bar code technology. 9(2010)
12. Sinfield J V, Fagerman D, Colic O, Evaluation of sensing technologies for on-the-go detection of macro-nutrients in cultivated soil.70, 1(2010)
13. Adamchuk V I, Hummel J W, Morgan M T, On-the-go soil sensors for precision agriculture. 44, 1(2004)

14. Zhong Liu, Baoguo Li, Min Xu, Qiang Gao, The Design of County's Soil Information System Based on the open-source Web-GIS.30, 17(2014)