DESIGNING AND APPLICATION OF WEB-BASED GEOGRAPHICAL INFORMATION SYSTEM FOR VISUAL ASSESSMENT OF LAND LEVELS

Ri NamSong, Choe JongAe and Kim Jonggun

Institute of Information Science, Kim Il Sung University, D.P.R. of Korea

Abstract

This paper deals with the way to design and apply a web-based Geographical Information System which will help the users see spatial data like land levels through web Visualization tool. The developed application shows that by using solely Open Source software it was possible to develop a customizable web-based GIS application that provides functions necessary to convey environmental data to experts and non-experts alike without the requirement of proprietary software.

Keywords:

Web-Based Geographical Information System, WMS, WFS, WCS

1. INTRODUCTION

Web-based Geographical Information System (GIS) can be used in all fields of the national economy as it can gather, store, control, and analyze a massive and variable geographical data through a computer network [1][2]. The visualization of a map data will help to understand a complex geospatial data better, and will facilitate better designing, planning and resource management [3]. Many web-based Geographical Information Systems have been being developed across the world recently, which can be used for different purposes such as the survey of spatial distribution of soil, landscape, weather conditions and climate, and their interrelationships, and for the land management in agricultural sector. Examples are plot-map program [4], grassland management system [5] and others, newly developed with the help of GIS. Some researchers try to help the users get a timely and useful information related to soil, landscape, weather conditions and climate, and visually analyze a space-time patterns of landscape. Previous software consists of 3 components such as ESRI ArcIMS, web server software, and data-base management system. ArcIMS integrated program consists of the client, data-base server interface, data-base server and spatial data server and so on. The last user uses the programs that support map reading and query function of spatial data, while data-base server interface is linked to web server like Apache and ArcIMS server. The first map on the internet was a simple one made with static image files (for example GIF), and later, in mid-1990s, came JavaScript with which users could expand, contract and make inquiries about data. With the rapid development of internet, came many web map applications such as MapGuide, Mapquest, MultiMap, and ArcIMS and many open-source products for nationwide information-based geography [6]. With the development of many web GIS applications, the standardization of web map service was needed, and as a result, a web map service standard was made, which has been being revised and supplemented until now [7]. Web Geographical Information System which accords with this standard, works as follows. Web Map Service (WMS) produces image data files containing geographical information and sends the static map to a client [7]. Web Feature Service (WFS) sends feature information and caters for the user's inquiry. Therefore rendering the user requested data - dependent on file size - takes noticeably longer than WMS map images. WFS also allows clients to edit stored layers [8]. Web Coverage Service (WCS) supports electronic retrieval of geospatial data as "coverage" (digital geospatial information representing space-varying phenomena). The WCS returns the original geo referenced data together with its associated attribute data thus providing opportunities for data exploration and interpretation [11]. For the geodatabase, two popular open source database management systems (DBMS) were considered: MySQL and PostgreSQL (coupled with PostGIS). Both of these DBMS have very powerful spatial support systems incorporated into them but in terms of spatial functionality, PostgreSQL-PostGIS appeared to have a larger range[13] thus allowing for greater potential of expansion of the developed web GIS software in the future. This potential, coupled with PostgreSQL-PostGIS being chosen by many of recent web GIS solutions [12] [14] [15] and [16] lead the authors to choose this geodatabase for this project. The map server makes it possible to access and display spatially enabled content of the geodatabase and enable querying and analysis of the displayed data. It works by storing data as tables in the database that can be later viewed as layers of a map [12]. As with the geodatabase solutions, there were two open source map servers considered: MapServer and GeoServer. Reviewing previous studies [17] [15] and discussion for-ums and it was deemed that the functionality between these two packages was quite similar and both packages would provide the level of functionality required for the project. GeoServer was subsequently chosen due to the developer's preference of its web administrator tool to aid in the testing and development of the web GIS system.

In our country, too, the assessment of atmospheric environment, the assessment of location factor of forest, temperature calculation were done with a Geographical Information System, and research has been done for its visualization [10]. This paper discussed the method of designing a web-based Geographical Information System for visual assessment of land levels.

2. DESIGN OF WEB-BASED GEOGRAPHICAL INFORMATION SYSTEM FOR VISUAL ASSESSMENT OF LAND LEVELS

The design of web-based Geographical Information System for visual assessment of land levels is as follows Fig.1. The client side consists of a development tool for experts and reading tool (web reading tool). The reading tool is an application for the map service and its examples are Google Chrome, Mozilla FireFox and so on.
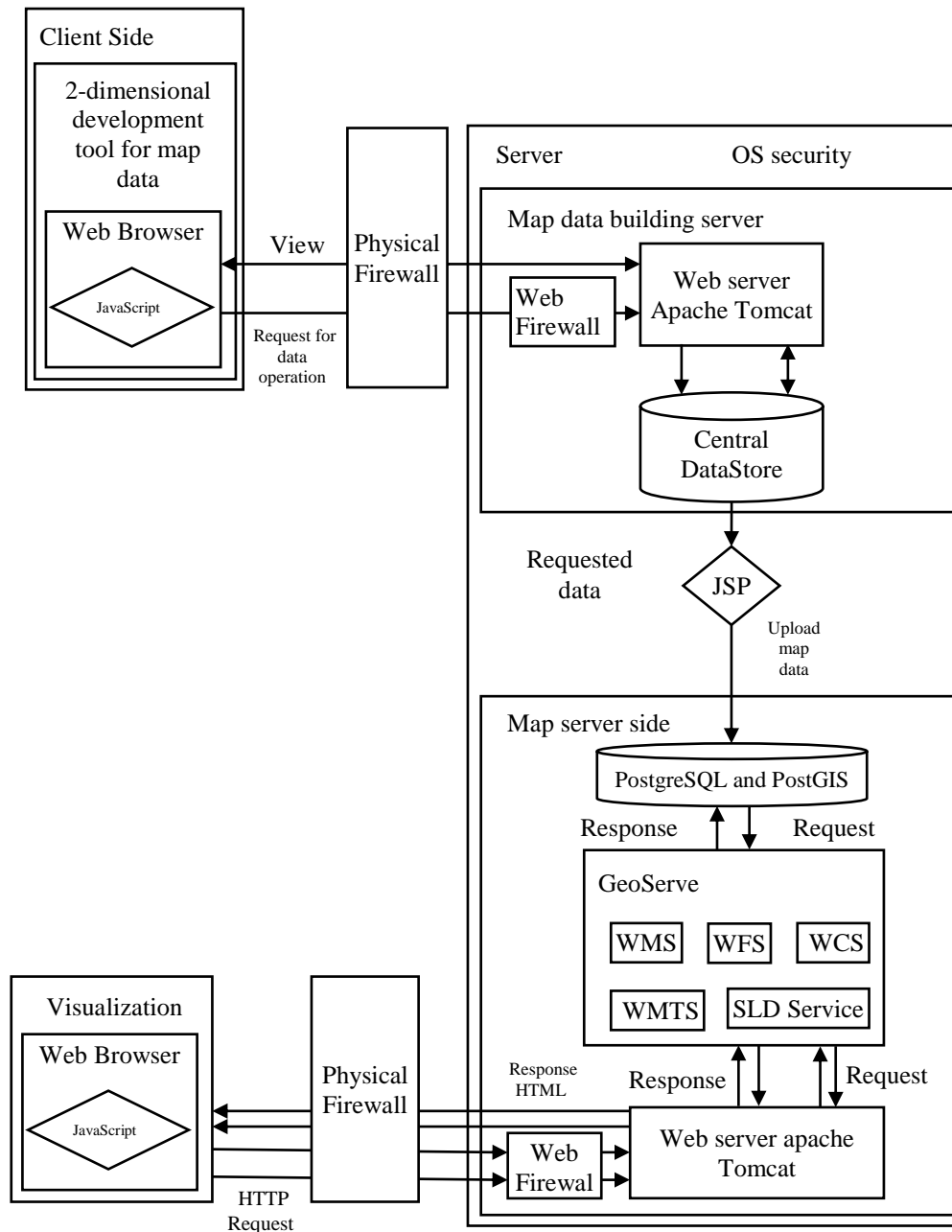
Fig.1. Design of web-based Geographical Information System for visual assessment of land levels

The server side consists of map-data-building server and geographical information server, and this geographical information server consists of web server, map server, and map database server. Web server uses Apache Tomcat, and map-data-building server builds image data and vector data for Central Data store. A map server can work for web map service (WMS), web feature service (WFS), web coverage service (WCS), web map-fragment service (WMTS), SLD service (Styled Layer Descriptor) and so on. Here PostgreSQL & PostGIS server is used as a map database server. The direct call on GeoServer of server and communication relation by client don't exist. By constructing physical firewall between client and server the physical stability of communication is supported. Server uses the security function of OS and supports the security using web service port by passing web firewall at HTTP request on web server. The HTTP request from client is transmitted to web server by passing physical

firewall, OS firewall and web firewall. Web server analyses the corresponding request and responds by combining with GeoServer. The working procedure of web-based Geographical Information System for the assessment of land levels.

2.1 PROCESS OF BUILDING MAP DATA BY A MAP DATA EXPERT

- Map data expert sends requests for spatial data management to map-data-building server by means of the 2-dimensional development tool of map data.
- Map-data-building server stores the requested spatial data at central data store in the form of files.
- Map-data-building server analyzes the stored spatial data before storing them in a database.

- Map-data-building server uploads the analyzed spatial data onto the map database server.
- Map database server stores uploaded spatial data in a database.

2.2 REQUEST AND RESPONSE PROCEDURE FOR MAP SERVICE

- The user sends requests for map service to the geographical information server.
- Web server of geographical information server hands over the requests to the map server.
- Map server sends map data queries to map database server.
- Map database server sends the needed map data to the map server.
- Map server analyzes the map data before making a visualized map and sends it to the web server.
- The user receives the visualized map from the web server.

2.3 REQUEST FOR SLD SERVICE AND RESPONSE

SLD service applies the style selected on the visualized map and shows itself on the basic map layer as a particular layer. Procedure of requesting and responding to SLD service is as follows.

- The selected Style request is sent to web server.
- Web server sends requested information to SLD server.
- SLD server sends result of the requested Style to web server.

Web server analyzes the response of Style before sending it to the client side.

3. REALIZATION

Generally, the growth of a plant is largely dependent on the edaphic condition, landscape, weather conditions and climate, and water supply. There are dozens of factors influencing its growth,

and the factors are as follows. Edaphic factors include the thickness of land-covering material, the thickness of humus, composition of particles, structure of inner layer, kind of soil, distinctive earth layer, depth of soil, valid depth of soil, ground and accumulation, potential of hydrogen, content of humus, content of nitrogen, content of phosphor, content of potassium, dryness and moisture, and the depth of underground water, and the landscape-related factors include kind of landscape, location, altitude, shade and light, compass direction, slope angle, and the length of slope.

Weather conditions and climate factors include 5°C accumulative temperature, 10°C accumulative temperature, 15°C accumulative temperature, but the drainage canal belongs to water-related factor. First, we have studied edaphic factors, landscape factors, weather conditions and climate factors, water-related factor for the assessment of ecological environment of crops, and on the basis of it, have assessed the levels of the land.

3.1 MODEL FOR THE ASSESSMENT OF LAND LEVELS

P: plot

$I = \{i_1, i_2, \ldots, i_n\}$: set of influencing factors

$G = \{g_1, g_2, \ldots, gm\}$: set of crops

$M = \{m_i \mid$ Weight corresponding to g_i, $i=1$, $n\}$: set of weights

$B_j = \{b_i \mid$: Base level corresponding to influencing factor ij for the crop g_i, $i = 1$, $m\}$: set of Base level corresponding to influencing factor ij

$B = \bigcup_{j=1}^{n} B_j$: set of base levels

$U = \{u_1, u_2, \ldots, u_n\}$: set of influencing factors in a plot

$A = \{a_i \mid u_i \subseteq B_j, i\}$: set of levels of crops in a plot

The level Average (Avg) of a plot is as follows.

$$Avg = \sum_{i=1}^{m} m_i a_i \qquad (1)$$

Table.1. Influencing Terms of herbage by land levels

Herbage	Land level	Humidity	Humus	Particle	pH	Direction	Elevation	Nitrogen	Phosphor	Potassium
Grass	1	8-10	3-6	4-7	5.6-7	10-16	600-800	8-12	2.5-8.9	10-15
Grass	2	6-8	2-3	3-4	5.1-5.6	6-10	400-600	12-80	8.9-10	15-20
Grass	3	4-6	1-2	2-3	4.6-5.1	2-6	200-400	5-8	1.5-2.5	5-10
Grass	4	1-4	0.5-1	1-2	4.1-4.6	1-2	100-200	1-5	1-1.5	1-5
Grass	weight	0.3	0.2	0.1	0.1	0.05	0.1	0.05	0.05	0.05

Table.2. Estimated result by the plot

Plot	Grass1		Grass2		Grass3		Grass4		Grass5		Land level
	Estimated level	Weight	Estimated level	Weight	Estimated level	Weight	Estimated level	Weight	Estimated level	Weight	
108	4	0.16	3	0.16	2	0.34	1	0.51	3	0.4	2
109	4	0.16	3	0.16	2	0.34	1	0.51	3	0.4	2
110	2	0.18	2	0.18	2	0.39	1	0.51	3	0.4	2
111	2	0.19	2	0.19	2	0.44	1	0.48	2	0.39	2
112	1	0.13	1	0.13	2	0.38	1	0.52	3	0.35	1

The algorithm for assessment of land levels is as follows,

• Set the weighted values of influencing factors needed by cereal and bean crops per each land level.

• Determine the influencing factors needed by each crops.

• Estimate the influencing factor by selecting different survey points per each plot.

• Calculate the average value per each crops.

Average value = influencing factor parameter × influencing factor on survey point × weighted value of influencing factor

• Determine the plot level by the average of average values per survey points corresponding to the plot.

3.2 APPLIED INTERFACE

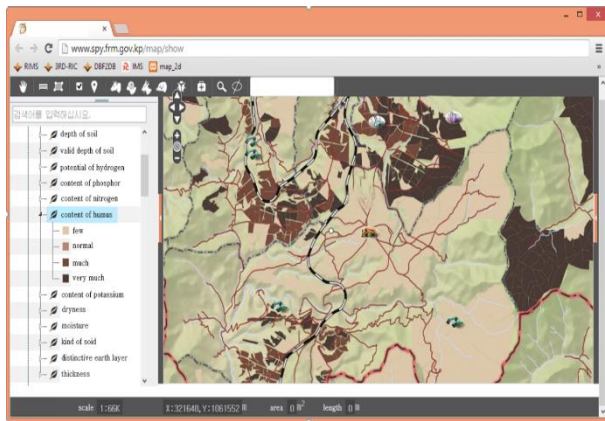Visual assessment of the content of humus is shown at Fig.2.

Fig.2. Visual assessment of the content of humus

Dark brown color in Fig.2 shows high content of humus but light brown color shows low content of humus. Visual assessment of the content of nitrogen is shown at Fig.3. In the Fig.3, we see the dark brown part contains much nitrogen but light brown part contains less nitrogen. In this way 28 influencing factors can be visualized.
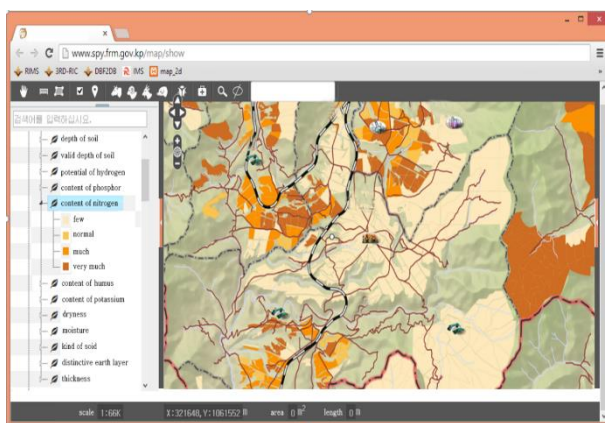

Fig.3. Visual assessment of the content of nitrogen

The following tables show the calculated results about the assessment of land level. The Table.1 shows the influencing requirement of crops per each land level. The Table.2 shows land levels evaluated by assessing fitness of crops on the plot.

Visual assessment of land levels of the area *L* is shown at Fig.4. Next, on the basis of visual assessment, land levels of the area *L* have been assessed visually. In Fig.4, the first-class plot is of green color, second-class plot is of blue color, third-class plot is of violet color, and the fourth-class plot is of pink color. This application program enables the specialists and experts to make an assessment of land levels without resorting to a patent.
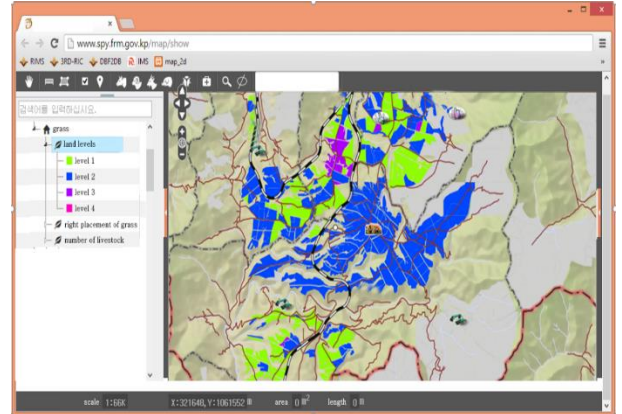

Fig.4. Visual assessment of land levels of the area *L*

4. CONCLUSION

In this paper the web-based geographical information system for visualizing and managing spatial data such as land levels through web browser has been designed and realized. The issues focused in the paper are as follows,

• First, it has designed a web-based Geographical Information System for the assessment of land levels. This system has been designed by combining Geoserver, PostgreSQL, OpenLayers and software for managing a map data. Map server performs web map service (WMS), web feature service (WFS), web coverage service (WCS), web map-fragment service (WMTS) and so on. And the server performs SLD service based on the realistic and dynamic spatial data such as land survey data and variation. This system can be used for different purposes such as land survey.

• Second, it has proposed a model of land levels, and introduced a visual assessment method of land levels into the stockbreeding bases in some area. Here the assessment of land level has been performed on the basis of assessment of ecological environment of crops by considering the edaphic factors, landscape-related factors, weather conditions and climate factors, water-related factors and so on. Amenably to the land levels, it could help to support the rational distribution of plantable feed crop, to choose the available farm stock, to calculate the number of livestock. It could help to get the improvement measure for increasing land levels such as increasing the content of nitrogen, phosphor and potassium.

REFERENCES

[1] P. Elliott and D. Wartenberg, "Spatial Epidemiology: Current Approaches and Future Challenges", *Environmental Health Perspectives*, Vol. 112, No. 9, pp. 998-1006, 2004.

[2] E.K. Cromley and R.G. Cromley, "An Analysis of Alternative Classification Schemes for Medical Atlas Mapping", *European Journal of Cancer*, Vol. 32, No. 9, pp. 1551-1559, 1996.

[3] C.A. Brewer and L. Pickle, "Evaluation of Methods for Classifying Epidemiological Data on Choropleth Maps in Series", *Annals of the Association of American Geographers*, Vol. 92, No. 4, pp. 662-681, 2002.

[4] A. Srivastava et al., "GIS based Malaria Information Management System for Urban Malaria Scheme in India", *Computer Methods and Programs in Biomedicine*, Vol. 71, No. 1, pp. 63-75, 2003.

[5] H. Crabbe, R. Hamilton and N. Machin, "Using GIS and Dispersion Modelling Tools to Assess the Effect of the Environment on Health", *Transactions in GIS*, Vol. 4, No. 3, pp. 235-244, 2000.

[6] Q. Yi et al., "Integrating Open-Source Technologies to Build Low-Cost Information Systems for Improved Access to Public Health Data", *International Journal of Health Geographics*, Vol. 7, No. 2, pp. 29-37, 2008.

[7] OGC-Open Geospatial Consortium, Available at: www.opengeospatial.org/standards/wms

[8] M. Miler, D. Odobasic and D. Medak, "An Efficient Web-GIS Solution based on Open Source Technologies: A Case-Study of Urban Planning and Management of the City of Zagreb", *Proceedings of International Conference on International Federation of Surveyors*, pp. 16-20, 2010.

[9] A.M. MacEachren, S. Crawford, M. Akella and G. Lengerich, "Design and Implementation of a Model, Web-based, GIS-Enabled Cancer Atlas", *The Cartographic Journal*, Vol. 45, No. 4, pp. 246-260, 2008.

[10] Cross Compare SQL Server 2008 Spatial, Available at: https://www.bostongis.com/PrinterFriendly.aspx?content_name=sqlserver2008_postgis_mysql_compare.

[11] S. Toutant et al., "An Open Source Web Application for the Surveillance and Prevention of the Impacts on Public Health of Extreme Meteorological Events: the SUPREME System", *International Journal of Health Geographics*, Vol. 10, No. 39, pp. 332-339, 2011.

[12] WMS Performance: Mapserver and Geoserver, Available at: http://2007.foss4g.org/presentations/view.php/120.html.

[13] D. Caldeweyher, J. Zhang and B. Pham, "OpenCIS-Open Source GIS-based Web Community Information System", *International Journal of Geographical Information Science*, Vol. 20, No. 3, pp. 885-898, 2006.