Design and Realization of Thematic Mapping in Web3DGIS

Guang Zhu

Beijing University of Civil Engineering and Architecture
Beijing, China
E-mail: zhuguang@bucea.edu.cn

Wenhao Qiao

Beijing University of Civil Engineering and Architecture
Key Laboratory for Urban Geomatics of National
Administration of Surveying, Mapping and Geoinformation
Beijing, China
E-mail: qiaowenhao@gmail.com

Abstract— **thematic mapping is an important module of GIS. With the development of technology such as 3D visualization and network communications, how to realize and optimize the thematic mapping based on Web3DGIS has become a hot research topic of GIS. This article has designed and realized a Web3DGIS platform based on Rich Client / Server, and adopted a thematic mapping method based on geometry. Through the method level-3 cache mechanism, the render efficiency of thematic mapping in the 3D scene and its expression ability has been effectively improved which has verified the feasibility of this method.**

Keywords-Web3DGIS; thematic mapping; vector data rendering; level-3 cache mechanism.

I. INTRODUCTION

Thematic mapping, which is an important functional module of GIS (Geographic Information System), can not only render and visualize the thematic information of GIS, but also conduct further space analysis and geographical analysis. Moreover, it could exploit the hidden mode and its development tendency. With the development of technology such as 3D visualization and network communications, to efficiently realize the thematic mapping based on Web3DGIS has become a hot research topic of GIS [9]. Currently, there are mainly two kinds of thematic mapping methods with vector data and based on Web3DGIS. First, Thematic mapping method based on geometry. Second, Thematic mapping method based on texture [8].

Thematic mapping method based on geometry means rendering vector data dynamically according to the terrain surface, and the vector data exist in 3D scene as 3D feature. However, this method would cause large system overhead [3]. Thematic mapping method based on texture means transforming vector to raster data, and to load vector data into 3D scene like raster data. This method saves system overhead that theoretically can support mass data, but does not benefit for interactive data [1].

The thematic data, thematic symbol and the method of interaction are more complicated in 3D scene. ArcGIS adopts the thematic mapping method based on geometry, but it cannot support the large amount of vector data well, so the interaction capability is limited partly. Google Earth renders thematic map with KML, and rendering data with high-efficiency, however the KML limits the interaction too much. WorldWind adopts the method combining geometry and texture to render thematic map, but if the volume of data is too large, the rendering efficiency is not ideal.

In order to solve the problems which mentioned above, this article designed and realized a Web3DGIS platform based on Rich Client / Server, and adopted an optimized thematic mapping method based on geometry. Through technologies level-3 cache mechanism, the efficiency of rendering and the ability of mapping have been improved successfully in the GIS thematic mapping.

This article is organized as following: Section II presents the core idea of the solution. In Section III, the main method of thematic mapping in 3D scene via Rendering of 3D scene, Level 3 cache mechanism, and thematic data rendering are presented. Section IV focuses on the realization of the Web3DGIS, while Section V presents details on an application case for the Web3DGIS. Section VI concludes the paper.

Research purpose: 1. Enhancing thematic mapping (based on vector data) efficiency by Level 3 cache mechanism. 2. Reinforcing the interaction capability of thematic map by rendering vector data based on geometry.

II. SOLUTION

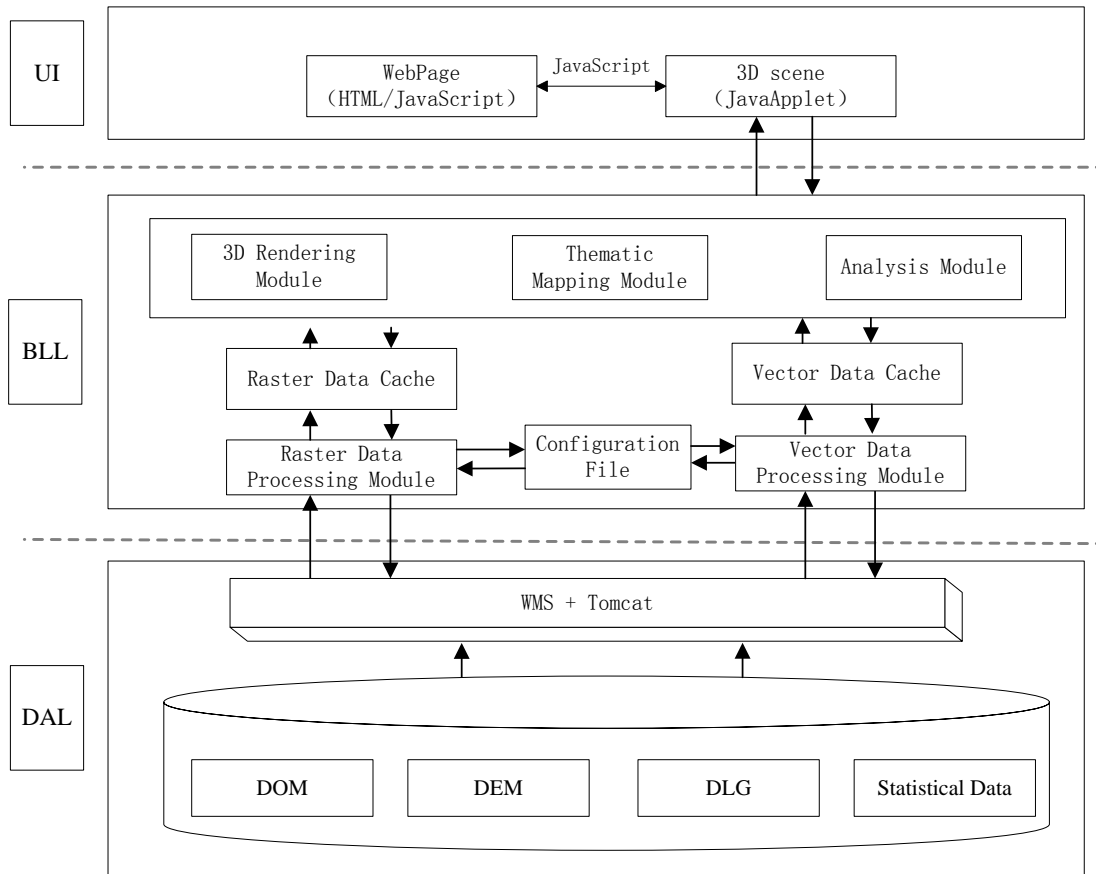The Figure 1 is the architecture of Web3DGIS platform.

Figure 1. Architecture of the Web3DGIS platform.

The server is composed of DAL (Data Access Layer), publishes the pyramid of raster data in the database through WMS (Web map service) which follows OGC's (Open Geospatial Consortium) principles. In addition, publishes website information and vector data through Tomcat. The browser side is composed of BLL (Business Logical Layer) and UI (User Interface). After acquiring the data from the server side establishes cache specific to raster data and vector data respectively. Therein, raster data (DOM (Digital Orthophoto Map), DEM (Digital Elevation Model)) cache is used to establish 3D scene, and vector data cache is used for thematic mapping and related analysis. Considering the generality of data, the vector data in this article takes "Shapefile" as the main data source.

The BLL is the core of the architecture. After acquiring the data from DAL, which based on the configuration file, the BLL import raster data into raster data cache via raster data processing module and import vector data into vector data cache via vector data processing module. Finally, the data in the two caches will be transferred to 3D rendering module, thematic mapping module, and analysis module, in order to render and analysis of the thematic mapping.

III. RENDERING THEMATIC MAP IN 3D SCENE

A. Rendering of 3D scene

In this article, the server-side publishes LOD (Level of Detail) image tiles of DOM and DEM which adopts the WMS standard of OGC (Open Geospatial Consortium) [6]. The browser side organizes and schedules image tiles by quad tree index mechanism, loads data into the scene, establishes digital elevation model in the 3D scene by DEM tiles, renders surface images by DOM tiles, and completes the production of base map of thematic mapping and the construction of 3D scene [2].

B. Level 3 cache mechanism

The thematic mapping in this article mainly depends on spatial data of vector data (.shp, .shx, .prj) and attributes data (.dbf). Through renders thematic mapping by spatial data, calculates and renders pie chart and histogram by attribute data, etc. In the mean time, this article adopts a kind of level 3 cache mechanism to make thematic mapping, in order to improve the speed of data access and rendering speed of thematic mapping. Figure 2 indicates the structure of the rendering module of thematic mapping.

In Figure 2, the vector data loader loaded vector data and transferred part of the data to vector data cache, and then the loader and the cache transferred the data to vector data

complier together for compiling. At last, the compiler transferred the data stream to vector data rendering module and 3D thematic symbol rendering module to render or analyze the data.
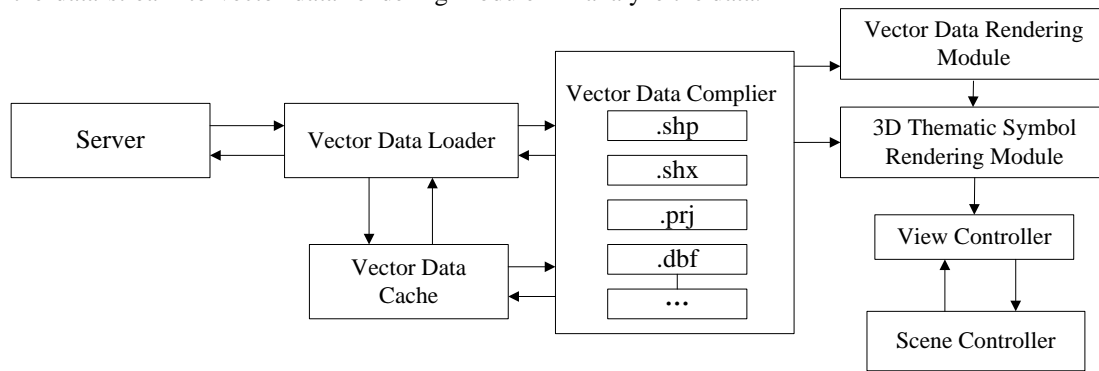

Figure 2. Architecture of the thematic mapping rendering module.

With the purpose of accelerating the speed of thematic mapping in the 3D scene, this article improves the method of active thematic mapping. Level 3 cache display mechanism is based on the traditional Level 2 cache display mechanism, for rendering thematic mapping. Level 2 cache display mechanism is to add a backup cache for organizing data to be displayed in advance on the basis of original main cache in the memory. The main cache data is used to display current scene, and the backup cache organizes data used by next scene. Level 3 cache mechanism is to add a HDD (Hard Disk Drive) cache for the interaction with server data on the basis of Level 2 memory cache. The HDD cache would be saved in the directory of browser local cache and the vector data accessed at the server side would be saved under this cache directory in the form of compressed package. Therefore, when users are to access the data again or to render again, the access request would directly go to the local data which accelerates the speed of data accession and rendering.

C. Thematic data rendering

After the data being compiled by vector data compiler, based on Level 3 cache mechanism, the vector data rendering module, the 3D thematic symbol module, and scene controller will accomplish the rendering of the thematic map.

- Actually, rendering the vector data is to render the projection along the vertical direction on the terrain surface [5]. This article adopted a vector rendering method based on geometry, the core of which is rendering the vector data which is created to adapt the terrain surface. If the data adapts the terrain surface, we will compute its projection and draw it on the terrain; if not, we need to introduce some new vertexes or segments to make the data adapt the terrain surface. This way, the vector data exists in the thematic map as an "Object", while displaying the thematic map; it can also provide some analysis capability. In the meantime, there are different datasets that point to different space or time, so we should divide vector into different layers to display different thematic data by different color or symbol. At last, to reduce the loading quantity of the thematic

map, controlling the visual range of the vector by the scene controller is needed. Figure 3 is the schematic diagram of rendering vector based on geometry. The broken line means the surface of terrain and the straight line means the vector data, we made the straight line adapt the broken line by introduced some new vertexes or segments.
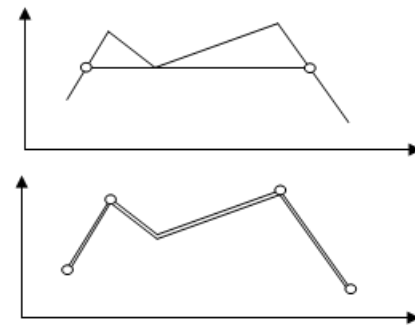

Figure 3. Schematic diagram of rendering vector based on geometry.

- Rendering thematic symbol is a kind of extension of rendering vector data in 3D scene [7]. While inheriting the method that renders vector based on geometry, we confirmed the coordinate via the spatial data of the vector data and height, color of the pie chart (histogram) via the attribute data of the vector data. In practical applications, using only figure to present the thematic map is not accurate enough; so, rendering the accurate value at the top of pie chart (histogram) is needed. The method we adopted in this article is locating the coordinate of the value to be rendered at the center of the pie chart (histogram) top surface, and overlaid the value layers on the pie chart (histogram) layers to avoid the value layers to be covered. In the meantime, the thematic symbol provides some interaction capability such as allowed user to measure or select the vector data and rendering the thematic symbol immediately, etc.

IV. REALIZATION OF THE WEB3DGIS PLATFORM

The Web3DGIS platform in this article adopted the rich client / server technology. The server is developed by C++, while integrating WMS [11] and Tomcat [12] and publishing the raster tile data and vector data, etc. The client is realized by webpage embedded a JavaApplet which is based on JOGL (Java Bindings for OpenGL). The JavaApplet takes charge of rendering the 3D scene, the thematic map and providing the application interface, and JavaScript will realize the interaction between the webpage and JavaApplet by the interface. Figure 4 is the architecture of the JavaApplet.
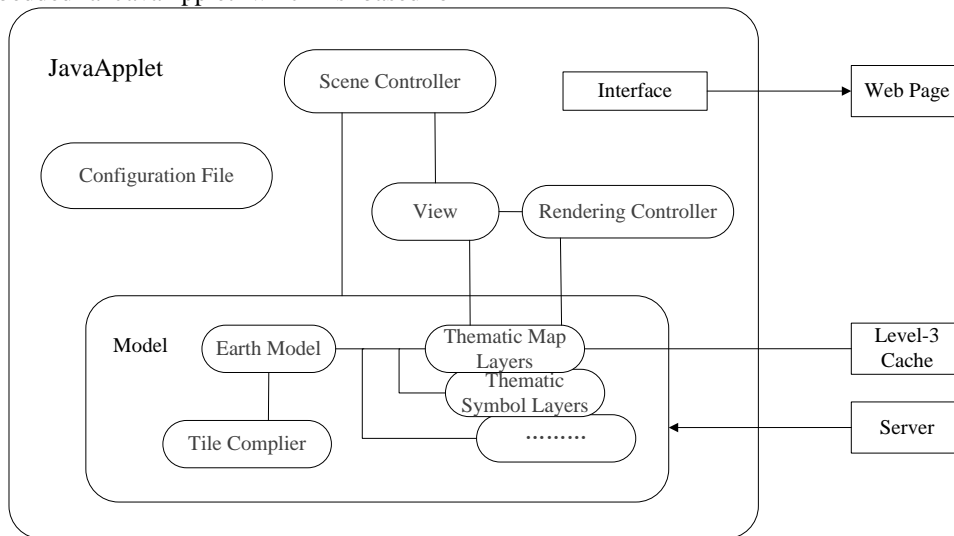

Figure 4. The Architecture of the JavaApplet.

The JavaApplet is realized by MVC (Model–View–Controller) [13][11]. The model part structured the 3D scene via raster data pyramid and loaded the thematic map in 3D scene according to spatial reference system; the view part displayed graph and transformed the coordinate from spatial to view via four-dimensional matrix; the scene controller and the render controller listened, handled the operation from user together, and displayed via the view part.

V. APPLICATION CASE

The WEB3DGIS platform, which was designed and realized, has been used for multiple regions in different industries; for instance, a city landscape management information system. It has realized garden thematic maps in different years, different regions and different types, via rendering vector data based on geometry (Figure 5), the thematic data query via the communication between JavaScript and JavaApplet and some interactive features such as measuring the greening rate of designated area (Figure 6) via the "object" feature of vector data which is mentioned above.
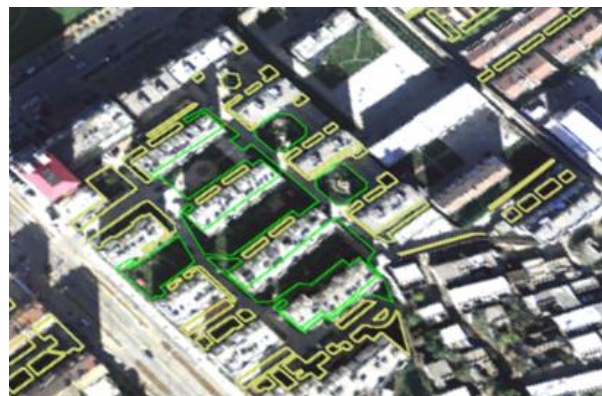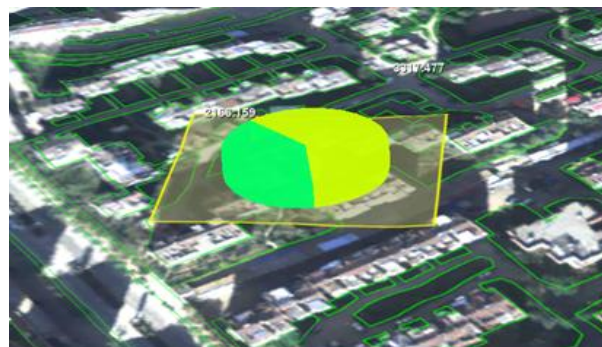

Figure 5. Thematic map.

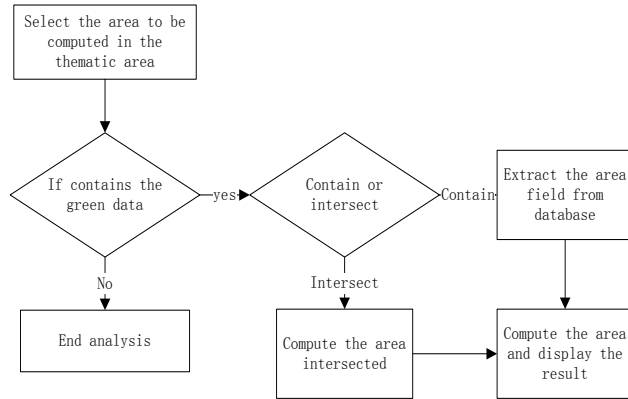Figure 6. The design sketch of measuring the greening rate.

Figure 7. The flow chart of measuring the greening rate.

VI.   CONCLUSION AND FUTURE WORK

Practice has proven that adopting optimize thematic mapping and combining with the technology of rendering vector data based on geometry can realize the function of thematic mapping practically and effectively under the Web3DGIS surroundings. The frame rate can maintain in more than 100 fps while the amount of data is less than 5GB and about 60 fps while the amount of data is between 5GB to 10GB. More importantly, it can not only realize fast rendering of thematic maps, but can also realize query and analysis, based on vector data.

However, the method mentioned above cannot be well-supported for massive amounts of vector data (more than 10G). In the next step, we will embed Hilbert-R Tree into the Applet. Scheduling vector by the index or Hilbert-Value of Hilbert-R tree, in this way, the efficiency of rendering vector would be further improved.

REFERENCES

[1] Q. Hu, "Research Based on the Integration of Two-dimensional Vector Data and Three-dimensional Terrain", Zhejinag University of Technology, 01.12.2009.

[2] H.M. Yao, T.J. Cui, S.X. Shao and J.F. Yuan, "LOD Terrain Model and Data Organization MethodBased on Quadtree Structure", Geomatics World, 2007, 12(6), pp. 56-59.

[3] P. Nazzareno, P. Fabrizio and C. Marco, "Thematic mapping at regional scale using SIASGE Radar data at X and L band and optical images", International Geoscience and Remote Sensing Symposium, IGARSS 2011 – Proceedings, IEEE, 2011, pp. 1095-1098.

[4] B. Leonhard and W. Frank, "Shallow landslide susceptibility mapping using stereo air photos and thematic maps", "Cartography and Geographic Information Science", IEEE, 2010, pp. 105-118.

[5] M. Scheider and R. Klein, "Efficient and Accurate Rendering of Vector Data on Virtual Landscapes", Journal of WSCG, 2007(1), pp. 59-65.

[6] A.S. Tang and O. Ertz, "Towards Web Services Dedicated to Thematic Mapping", OSGeo Journal, 2007(3), pp. 31-34.

[7] R. Yuri and F. Luciano, "Construction of seafloor thematic maps from multibeam acoustic backscatter angular response data"Mayer, Larry, "Computers and Geosciences", IEEE, 2012, pp. 181-187.

[8] S. Zlatanova, A.A. Rahman and M. Pilouk, "Trends in 3D GIS development", Journal of Geospatial Engineering, 2002, Vol. 4, No. 2, pp. 1-10.

[9] Y. Pan, "A Thematic Map Making Mode Based on GIS", "Bulletin of Serveting and Mapping", 2005, Vol. 9, pp. 28-40 .

[10] D. C. Roy and V. Coors, "3D web-based GIS for flood visualization and emergency response", "Society of Petroleum Engineers - 73rd European Association of Geoscientists and Engineers Conference and Exhibition 2011 - Incorporating SPE EUROPEC 2011", IEEE, 2011, pp. 1001-1005.

[11] http://www.opengeospatial.org/standards/wms: Dec. 2012.

[12] http://tomcat.apache.org: Dec. 2012.

[13] http://en.wikipedia.org/wiki/Mode-view-controller: Dec. 2012.