A Framework of Web GIS Based Unified Public Health Information Visualization Platform

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Abstract. The GIS plays a vital role in public health information visualization for public health information management, broadcasting, data management, statistical analysis, and decision supporting. This paper described the elementary requirement and the essential technology for public health information visualization and proposed a framework of the unified public health information visualization platform based on the Web GIS and visualization technology. The system framework adopted multi-tier system infrastructure that consist the sever tier and the front tier. In the server tier, the J2EE based architecture was adopted to construct a distrusted system infrastructure. In the front tier, the GIS map java applet is used to show the public health information with spatial graphical map, and the web based graphics figures such as curves, bars, maps and multi-dimensional visualization technology are used to visualize the public health information. The public health information contained the geo-referenced data, such as specific location, area code, latitude and longitude, street address, and geopolitical boundaries can be visualized with GIS distribution maps. The system infrastructure, functions, system integration, and some key technology were discussed in this paper. It would have the important practical value for constructing the visible public health information system.

1   Introduction

The GIS plays an important role in public health information visualization. In the public health crisis, such as the burst of infectious disease, the geo-reference information visualization will be essential to protect people from the nature disaster. Web GIS based visualization information can be used for warning, monitoring, processing and controlling the emergent event with its visible spatial information. With the development of Internet, the Web GIS becomes a desirable technology for building the public heath information system to prevent against the infectious disease and public health crisis. It is an essential tool for sharing the infectious diseases information, rescuing the infectious patients, isolating virus source area, and sending out the alarm to the public in short time [1-3].

GIS has been used for public heath area for long time. As early as in 1854, Dr. John Snow had used a map to track the original area where the cholera disease erupted in London in first time. From that time, map had been used in the infectious disease controlling and preventing, and it becomes an essential tool in protecting the public health environment [4]. The research subjects of applying the GIS to the public health have attracted

much interest in recent years, especial after the eruption of SARS in 2003 [5]. The World Health Organization has used the GIS technology to forecast and analyze the spreading tendency of SARS with a GIS. ESRI Corporation has developed a WEB-GIS based information system to issuing the SARS distribution map in China and Hong Kong area. The SARS infected regions were shown with the visual technology in the map to report the SARS cases and distributed information to public. SarsNet, WHO and the Freach IN-SERM 444 research institute have developed an infectious disease supervisory system, which can be used to search the newest SARS surveillance statistical information from different nations and different time periods. The system has also provided the functions of searching the special disease information according to the geographical position and expressing the results with the visual technology. SarsNet also proposed SARS dissemination models, which can dynamically produce a new SARS distribution map to express developing information of SARS disease in next time [5,6,7,8].

In China, the Remote Sensing Institute of Chinese Academy of Science has conducted a knowledge innovation-engineering project named "Research on the SARS infectious situation information visible decision-making support environment" [9]. This project has applied the GIS technology to show spatial chart of the SARS infectious situation in China and Beijing area. The project has preliminarily investigated the relationship between the urban population transportation passenger flow and the SARS dissemination. They also have simulated the future SARS infectious situation. Their researches have provided the scientific foundation for understanding the SARS dissemination mechanism and provided a good tool for the SARS infectious situation controlling and the decision-making. In addition, the Science Geography Science and Resources Research Institute of Chinese Academy, the Beijing Supper Map GIS Company, and the China Infectious Disease Control Center also have conducted the research on Web-GIS based the public health application.

We started a research project on the SARS information management system for preventing and controlling the SARS disease from 2003. We have developed a Web GIS based interactive SARS information system, which can enable the public to participate in the prevention activities and reported the SARS information to the Health Cure Center. With that help of the system, the public and the medical worker could work together to explore and report the cases of illness, survey infectious disease area situation, isolate the infectious area in the shortest time.

In this paper we will report our research work on the elementary requirement and the essential technology in building the Web GIS based public health information visualization platform. The our research aims to apply the Web GIS based visualization technology for public health information broadcasting, data management, statistical analysis, and decision supporting. The research subjects of system infrastructure, functions, Web-GIS, web based visualization technology, system integration, and some key technological will be discussed in this paper.

2 WEB-GIS Based Public Health Visualization

Web-GIS is a technique that can set up geographical information system on Web. User can get the geographical information mutually by Web-GIS application through Inter-

net. It makes GIS function of system expand to web site by combining web with GIS technology. Various kinds of geographical space data, attribute data, picture can be obtained through web. With the rapid development of Web-GIS technology, GIS based applications can be developed with low costs, little maintain work. Web-GIS based systems have been popularizing in large scale [12,13].

While Web-GIS based system used the CGI based technology in early time, presently GIS java applet is mainstream technology as the front end in the browser to show the graphical map. In the CGI based Web-GIS system, web server transfers outside graphical user interface of GIS system. It expanded the network function of web server. The CGI is a bridge between graphical map interfaced and GIS application program in web server. Web server responds the request from web browser and transmits the GIS map and data information as picture, and sends the information back to the web browser.

Another technique to realize Web-GIS is to utilize ActiveX. The controlling parts and COM model technology are used to set up Web-GIS system. Microsoft Company provides the COM technology that can develop powerful Web-GIS system both in client/server and browser/server system structure. It also supports many kinds of development environments such as VB, VC, Delphi and PowerBuilder at the same time. With such technology, the GIS systems have the good flexibility and ability of expanding. To use the COM and ActiveX in the browser/server system structure, the COM
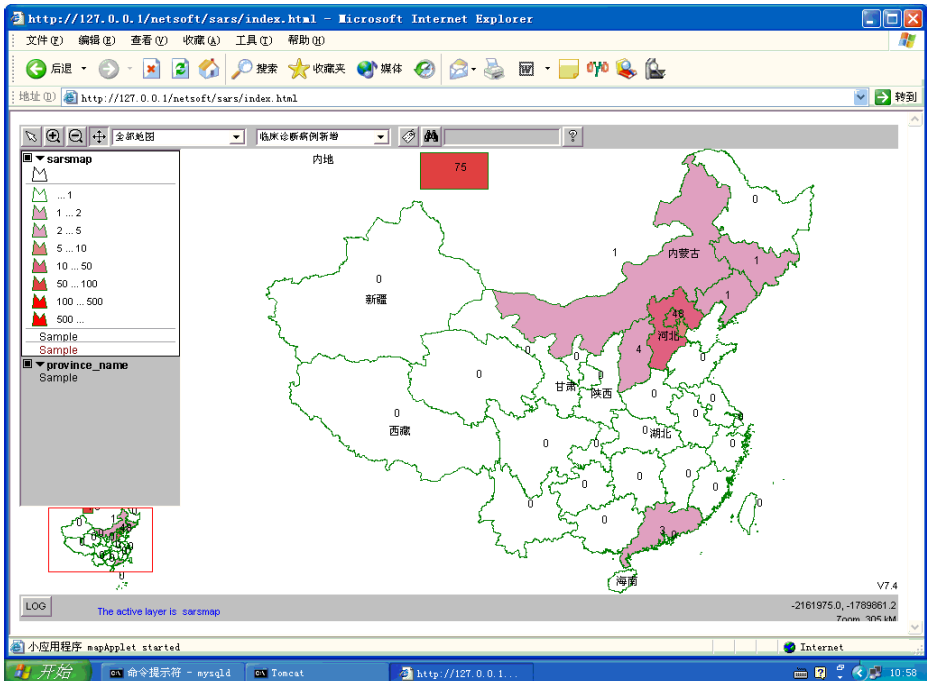

Fig. 1. Web-GIS based public health information visualization: distribution map with grade color to express quantities of infectious situation
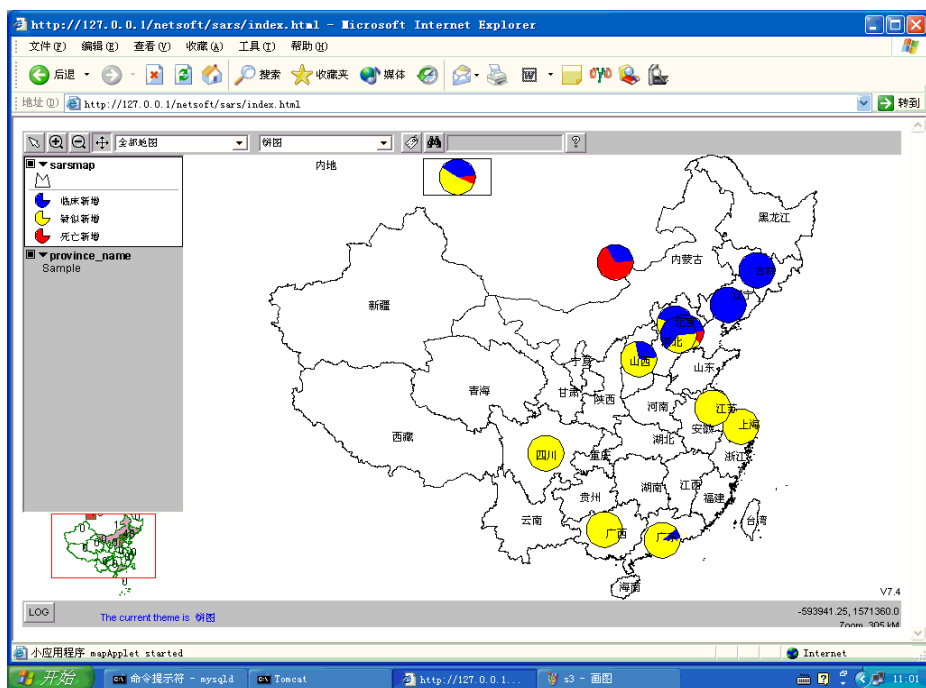
Fig. 2. Web-GIS based public health information visualization: Distributions map with the pie chart to express the public health information

and ActiveX serve as the plug-in in the browser. It is a good technique to set up Web-GIS system. There many Web-GIS application systems use this kind of technology. The plug-in gets the GIS data in server and display the graphical map in the browser. User can directly view and operate the graphical user interface by plug-in. It reduced consumedly the data transmitted in the network compared to the CGI based GIS system and solves the deliver bottleneck of graphical data in network. At the same time, plug-in also provides database operation function to view attribute data, search information, and operate the map by a graphical user interface.

The COM and ActiveX can only run in browser of IE produced by Microsoft Company and run on the Windows platform. It limits their application in other browser such as Netscape and other platform such as Unix operation system. Because java is platform independent, java GIS applet becomes the mainstream technique to establish the system of Web-GIS. The Java language is a language for network and object oriented. It seals object, dynamical inherit. With characteristic of object, overwhelming majority of data type appears in object form. Because Java adopts Virtual Machine technique, the target code has nothing to do with system platform. At the same time, it supports the distribute network computing. Because of these characteristics, java GIS applet becomes an ideal technique to realize the Web-GIS application. Presently GIS java applet is mainstream technology as the front end in the browser to show the graphical map.
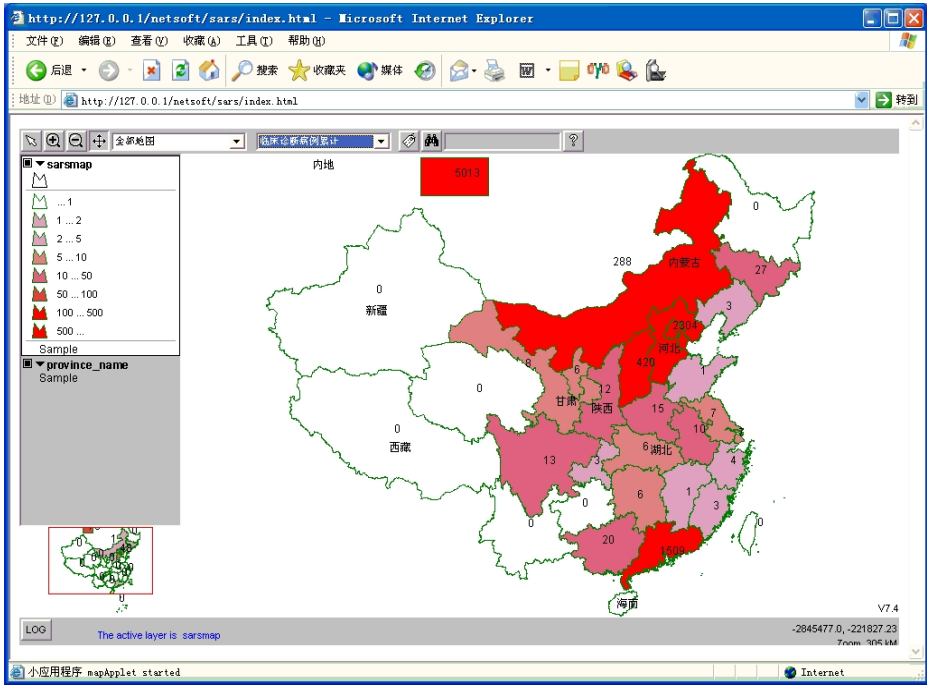
Fig. 3. Web-GIS based public health information visualization: a distribution map of accumulated infectious disease cases

2.1   The GIS Data and Public Health Information Visualization

By combine of the data of public health information with spatial data of GIS, distributing information of infectious disease situation can be visually displayed on electronic map of GIS. The infectious disease situation data such as the patient's number, the virus source areas can be shown at corresponding geographical position. The electronic map with GIS can realize the flowing functions [14,15]:

1) Necessary theme layers and marks;
2) Zoom in, zoom out, pan and selection functions on map;
3) Search functions such as the graphic objects search, the key words search, etc.;
4) Data inputting functions on map, such as the functions to input GIS relevant information in the corresponding area on the map.

Basic GIS and infectious disease situation data needed to be collected for setting up the distribution maps of newly increased case in real time. By connect with the GIS database, we can browse and search the basic public health information, infectious situation area, hospitals distribution in the area.

2.2   The Visualization of Infectious Disease Situation with Distribution Maps

There are several kinds of distribution maps: the distribution map of newly increased case and the distribution map of the accumulative total cases. Using the grade color
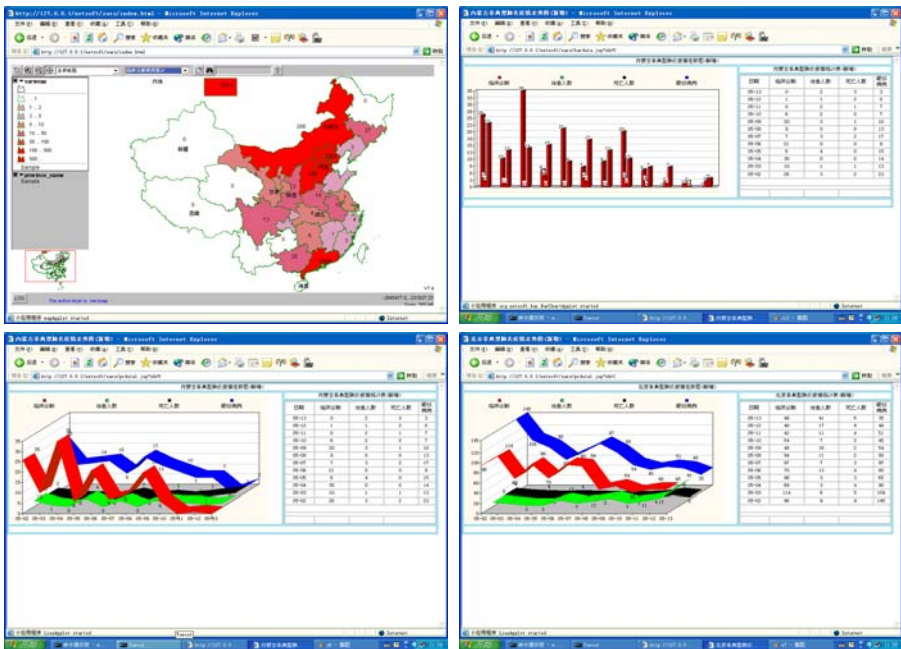
Fig. 4. The pictures show the visualization the relationship of the public health historical data and virus-developing tendency

can show the distribution situation information. The bar and pie pictures can be used to express the dimensional quantities of infectious situation.

The figure 1 to 3 shows the distribution map for public health information visualization with geo-reference data. The figure 1 shows a distribution map of newly increased infectious disease cases. The different color express different numbers of the cases, the legend figures are shown in the left. The figure 2 shows pie chart distribution map of percentage in newly increased cases, suspect cases, and death cases. The figure 3 shows a distribution map of accumulated infectious disease cases.

2.3 The Visualization of the Historical Data and Infectious Spreading Tendency

We can click on the map to inquire about the infectious situation of this area about the information of historical data, developing tendency, which can display visually three-dimensional line chart, bar to express the data of infectious situation.

The figure 4 shows the visualization of the historical data, virus-developing tendency.

1. The left-top picture is a distribution map.
2. The right top picture is a bar chart to show the historical data.
3. The bottom pictures are three-dimensional line charts to express the tendencies of infectious situation.

3   A Framework for the WEB GIS Based Public Health Information Visualization Platform

In order to setup up a visual work environment for public and hygiene department to research, statistical analyze and broadcast the public health information between the spatial graphical data and the infectious disease data, we proposed a framework for the Web GIS based public health information visualization platform.

Web-GIS applet can be used to get and show the geographical information for public in web site. Also, public can use the GIS java applet in browser to reporting the most recent public health information. After the message received from the public, there will be a serious of immediate actions, such as confirming the information, notifying relevant department, rescuing the patient, isolating the infectious disease area and broadcasting the information. The all processes will get many departments involved, such as hospital rescuer center, police station and relevant government department. The unified visualization information platform is a powerful assistant for achieving of communication, interactive operation, effective data processing, and GIS data visualization.

Because there is many computers with different kinds of operating system will work in coordination in the system, the distributed, platform independent system architecture needed. To enable application system be accessed by lots of different computers in network, we choice the J2EE and EJB technology that offer framework of service system to construct enterprise system structure.

The middleware of CSCW, GIS, and public health information EJB offers distributed transaction processing. Many host computers can join to offer the many services. Compared with other distributed technology, such as CORBA technology, the system structure of EJB has hidden the lower detail, such as distributed application, the events management, the target management, multi-thread management and connoting pool management etc. In addition, J2EE technology offers many kinds of different middleware to be applied to business logic. The data are stored and managed with EJB. Distributed computing enable users operate in any time, any place, and obtain business logic and data processing in remote server. The distributed systems enable the databases and services in the same or different computers. The databases consist of CSCW database, public health information database, and interoperable GIS information system database. The database uses JBBC to communicate with EJB (back-end server). The system front-end adopts JSP/Servlet. JSP and Servlet use the back-end work to provide service. The front end adopts a java GIS applet to communicate with JSP/Servlet and back end EJB in Browser.

System architecture is platform independent, multi-layers and distributed structure. It can combine GIS database, CSCW database, and many host computers together and share the system resource and data.

Web-GIS based public health information visualization platform should be considered and realized the following basic functions.

Information Sharing: The databases of GIS, public health data are the information center of the system. All the cooperating work and information sharing is dependent on

them. For example, when the public reports the infectious situation through system, the information will be stored in the database and be shared by others.

Human Computer Interaction Based on WEB-GIS: The Web-GIS is the basis graphical user interface of man-machine interface in the system. Based on WEBGIS, interoperable information visualization platform obtains the geographical position at the same time. The friendly interface and interactive system is convenient for information management.

4   Discussions and Further Work

We developed a framework of the unified visible public health information visualization platform based on the Web GIS technology. There are two components for the platform: the platform server end and the client end. In the server end, we will develop GIS server based on the J2EE framework. In the client end, we will investigate a visible harmonious cooperation user interface to realize the public health information visualization and cooperation.

Although we completed a framework the public health information visualization based on the WEB-GIS technology, there are still many technical problems to wait for the research:

(1) The different GIS spatial data frequently existed in different format document. The special GIS data format transform software is needs to translate the GIS data format (for example ARC/INFO, ArcView, MapInfo, ERDAS, and Atlas and so on). The system lacks the exchange standing for information and data and the resources cannot be shared by other system.
(2) The spatial data is usually huge (several hundred MB to several GB). The user must have enough storage and the bandwidth to transmission data. While in very many situations, user possibly only needs a small area of the whole map or the partial GIS data, not the complete spatial data. As a result of the network and the bandwidth limit, the system performance becomes very slow.

These problems are the essential technical problems, which need to be solved in building a Web-GIS, based the public health information visualization platform. The further research work will focus specifically on the following aspects:

(1) The essential technology that realizes the interactive and convenience man-machine user interface will be investigated to break the limitation of the WEB-GIS system.
(2) The visualization technology for the public health information data, such as 3D and the virtual reality technology (VR) would be considered to applying the simulation of the real public health environment. It will enhances the cognition effect in the interactive observation and the analysis public health environment
(3) The essential technology of data compression and data optimization are the bottleneck problems on the Internet transmission when the spatial data transferred from the far-end server to the browser in the Web GIS system.
(4) The system data specification of the public health information based on OGIS (OGIS, Open Geo-data Interoperable Specification) and SVG (Scalable Vector Graph-

ics) should be investigated to enable the geography data and the public health attribute data exchangeable between the different geographic information system software and system.

5   Conclusions

The public health information management is a socialized work that the public would be very important to participate in the activity for preventing and controlling the acute bursting infectious disease. In the process of preventing and controlling the acute bursting infectious disease, an Web-GIS based visible and interactive public health information operation environment will be helpful for the public to participate in prevention disease on their own initiative. The public and the hygiene department could be cooperated together to prevent and control the acute bursting infectious disease, rescue the patient, and isolate the infectious disease source area.

This paper proposed a framework of the unified public heath information visualization platform based on Web-GIS and virtualization technology. The Java GIS applet technology combined with web based visualization technology has been applied to the public heath information visualization of the geographical distribution and the historical developing tendency. It can be applied to the visualization of public health information management, such as information broadcasting, data management, statistical analysis, and decision supporting.

The Web-GIS based visible and interactive public health information visualization environment will be helpful to track infectious disease-spreading tendency, to build up the immunity isolation mechanism for the infectious disease, establish the best transportation line for the personnel and the equipment supply in the infectious region, dynamically issue the medical service health device information on the Internet. It may provide the tools for the visible infectious disease trend analysis, the visible medical service demand analysis, the hospital and the outpatient clinic location, the visible region analysis, and the resources and equipment management. It will have the important practical value and to protect the life and health, play a vital role in the visible public health information system construction.

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