Application of WebGIS to Disaster Information Management Based on Multi-Criteria Decision Making

Jing Chen and Qingjie Zhu
College of Civil Engineering and Architecture
Hebei Polytechnic University
Tangshan 063009, China
dmm711@163.com

Abstract—Publication of disaster information is in urgent need. It is necessary to investigate WebGIS resolution for data share and publication of disaster information. Through analyzing the technique function of WebGIS and the character of information network publication, the system application is developed based on MapXtreme in Windows 2000 Server operating system, which achieved the real-time publication of disaster information in server and the real-time browse in client. In order to improve the speed of data transmitting through Internet, ASP technique is combined with ActiveX controls. In recent years, considerable interest has been focused on the use of GIS as a decision support system. According to the results of Multi-Criteria Evaluation (MCE) in Tangshan City, system structure and resolution for Internet publication is discussed, system application is developed with network language VBScript and JavaScript language under the ASP environment. Finally, some advice is proposed for the development of Internet publishing system.

Keywords—WebGIS; decision making; disaster information; MCE; Tangshan

I. INTRODUCTION

As an effective management method, GIS has got an extensive application in disaster prevention, such as weather disaster, geological disaster, earthquake and so on [1]. But most of the GIS application is the desk product, which is developed by diverse GIS tools. Because data type is complicated and incompatible for each other, it is difficult for data sharing in time, and this disadvantage also makes users difficult to obtain useful information through Internet. Meantime, WebGIS has been applied in MIS development for many fields, such as communication infrastructure [2], geological data [3], land use dynamic management [4], and city planning [5,6]. Integration method between GIS and GIS-based model based on Web services is investigated [7]. Therefore, through applying WebGIS to the disaster prevention, data share of disaster prevention information will be resolution, and possible to make disaster prevention information become basic social information service, which is important for the construction of digital city.

With the widespread application of Internet, a computer network times is coming, which has many advantages, such as network management, system improvement, data sharing, and so on. Internet provides various services that are efficient for application and easily to be modified for every person in the world [8]. Through permit users to access, retrieve, display and analyze spatial data over web, WebGIS will change the manner of life, working, and data share. Data collection, modification and analysis for GIS are supported sufficiently by the convenient Internet. In the article, through combining Internet with WebGIS technique based on MapXtreme, management information system of natural disaster for Internet publication is investigated, in which the data share of disaster prevention information is resolution.

II. WEBGIS RESOLUTION

Resolution methods of WebGIS include: CGI (the Common Gateway Interface), GIS plug-in, ASP, ActiveX and Java language etc [9]. Common Gateway Interface (CGI) is a standard for interfacing external applications with information servers, such as HTTP or Web servers. The Common Gateway Interface is an agreement between HTTP server resolution about how to integrate such gateway scripts and programs. It can help the customer interact with the Web Server, but there are some disadvantages in this method, it is difficult to operate GIS graphics files by using the CGI programs.

GIS plug-in method, the plug-in is a kind of software downloaded from the server; it is used for exchanging information data with specifically format with the server. It can transfer parts of function in servers to the client. For WebGIS, the data vector is transmitted to the client and processed by the GIS plug-in. Therefore the reaction speed of the customer interacting with the server is accelerated, and most of the processing work is completed in the client.

ActiveX is an extension of Microsoft Windows and the Object Linking and Embedding (OLE) API. ActiveX applications are used mainly with Internet Explorer, Microsoft web browser. ActiveX control is similar to the plug-in that is designed to finish some task specifically and executed by web browsers. The difference is that ActiveX control can be re-used by many application programs within a computer or among computers in a network. In resolution, an ActiveX control is a dynamic link library (DLL) module. GIS ActiveX control is used to access GIS data and complete GIS analysis in the Internet. Usually, the GIS ActiveX control is labeled between the <OBJECT> labels in the code of HTML.

ASP stands for Active Server Pages is a server side technology that is used to display dynamic content on web pages. Microsoft Company designs it for Web server IIS5.0,
it is dynamic, effective, easily to learn, and it will replace CGI, ISAPI, and JDBC gradually. It does all works in the server side, and combines HTML page and Scripts language and dynamic server module together. Also, it can create HTML page for Web browser in the client side.

There are two methods to transmit spatial data from the Server to the client (user) in WebGIS. One method is transmitting picture data to the client; another is transmitting the space vector data directly to the browser [10]. Each has its advantages and disadvantages, when user need transmitting vector data, they usually need download some GIS plug-in that is used for transmitting and operating with server before they get information. Its advantage is fast; but there are also some disadvantages for the GIS plug-in, user only can complete some basic operations because of the function limit of GIS plug-in. One GIS plug-in is consistent with one type data specifically, this will restrict extensive application of Web GIS.

Another feasible method is transmitting GIS data to the client as picture format. MapXtreme of MapInfo Company is a WebGIS development tool with this method. MapXtreme is a map application server in the server side which transmitting data as picture format and providing powerful spatial data analysis services for user. In this method, all services and server configuration are made in the server side. Users can interact with server by the IE browser in the client side and no plug-in is requested.

In order to improve the speed for data transmitting in network, we select combining ActiveX control with ASP technique based on MapXtreme as resolution method. The natural disaster prevention information is shown to customer as asp web page through the system application. VBScript and JavaScript language are used to develop system application program under ASP environment. Real-time publication in server and real-time browse in client as picture format. MapXtreme of MapInfo Company is extensive application of Web GIS.

The fourth factor is site type, and there are three types of site, ‘favorable earthquake resistant area’, ‘moderate area’, and ‘unfavorably earthquake resistant area’. The most dangerous area is unfavorably earthquake resistant area. By surveying the distance from moderate area and favorable earthquake resistant area to the unfavorably earthquake resistant area, ascendant J-shaped function is selected for karst collapse, with point ‘a’ to 0, point ‘b’ to 12035. The third disaster factor is earthquake, and the most dangerous area is the highest earthquake intensity area in history. The farmost distance from the highest earthquake intensity area is 9500 meters, where the earthquake intensity is half of the highest area. Thus, ascendant sigmoid function is selected for earthquake, with point ‘a’ to 0, point ‘b’, c, and d’ to 19000. The fourth factor is site type, and there are three types of site, ‘favorable earthquake resistant area’, ‘moderate area’, and ‘unfavorably earthquake resistant area’. The most dangerous area is unfavorably earthquake resistant area.

According to above evaluation criteria, standardization of distance images is worked out, and suitability images for all factors are obtained. In WEIGHT module, corresponding comparison matrix can be constructed with different criteria. Each value of comparison matrix reflects the relative importance of factors. Generally, 9-point continuous rating scale is adopted. When the relative importance between factors can be expressed by a significative value, this value can be used in comparison matrix. If comparison matrix is constructed, it also can be edited in Edit module, and then uses it directly in WEIGHT module. Thus, the comparison matrix resulted from this technique is a positive reciprocal matrix. Therefore, only the higher/lower triangular half which includes n(n-1)/2 elements needs to be filled in.

After the pairwise comparison file is filled, individual factor weights and consistency ratio can be calculated. Values of consistency ratio less than 0.10 indicate good consistency. When values exceed 0.10, the comparison matrix needs to be modified, and the matrix of weightings should be re-evaluated. The results of this sample are 0.2077, 0.1164, 0.6248, and 0.0511.

Once the weights matrix has been determined, the module MCE can be used to aggregate factor images and the suitability image for Multi-Criteria Evaluation will be obtained. The aggregation method of weighted linear combination multiplies each standardized factor map by its factor weight and then sums all factor images. Thus, the results of suitability evaluation are worked out, which is shown as figure 1. From figure 3, it can be found that some unsuitable areas distributed in center district, so more attention should be paid for those areas and lower density for
construction should be insisted. Also, the suitability for land use increases gradually from southeast to northwest.

According to the disaster character of Tangshan City and the actual request to disaster prevention information publishing, the system disaster information model is constructed as the figure 3.

![Figure 1. Integrative influence of disaster factors](image)

IV. PUBLICATION SYSTEM DESIGN BASED ON WEBGIS

A. Structure Model

B/S (Browser/Server) structure of three layers is adopted by the system, which consists of Browser in the client, Web server (IIS5.0) and Map Server (MapXtreme). System application structure is shown as figure 2. Customers interact with server using the browser of IE in the client side; a great deal of data is analyzed and map information is processed by Map Server MapXtreme in server side. Information user is created by the system application which is transmitted to user in client side; Web server is only responsible for the data management work. Since most works are completed in the server side, customers can obtain information and analyze spatial data easily only by the Web browser.

![Figure 2. System structure](image)

B. System application development

Many system functions, such as zoom in, zoom out, cruise, information searching, layer control, automatic label etc., are completed through system application. System application is developed based on MapXtreme under Windows 2000 Server operating system. For example, main ASP files in the module of site type under the menu of site earthquake resistance include three files, Global.asp, CdkzxnConstants.asp, and Cdkzxn.asp. Files program codes are as follows,

```vbscript
<%! #INCLUDE FILE="...\lib\miConst.asp"%>
<SCRIPT LANGUAGE="VBScript" RUNAT="Server">
Sub Session_OnStart
Dim strDirname
Session.Timeout = 1
Session(cMapImageHeight) = 700
Session(cMapImageWidth) = 550
Session(cExportFormat) = "GIF"
Session(cExportFileExt) = "GIF"
strDirname = "/mapimage"
Session(cAbsMapPath) = Server.MapPath(strDirname) & "\"
Session(cRelMapPath) = "http://" & Request.ServerVariables("SERVER_NAME") & strDirname & "\"
Session(cImageFile) = ""
Session(cFileNamePrefix) = ""
Session(cFirstAccess) = True
Session(cMapPath) = ""
Set Session(cMapXObject) = Nothing
Set Session(cMapXCourierObject) = Nothing
![Figure 3. System information structure](image)
```
If InStr(1, Request.ServerVariables(cHttpUserAgent), cMozilla, vbTextCompare) <> 0 And InStr(1, Request.ServerVariables(cHttpUserAgent), UCase(cMSIE), vbBinaryCompare) = 0 Then
    Session(cClientBrowser) = cNetscape
Else
    Session(cClientBrowser) = cIE
End If
End Sub

Sub Session_OnEnd
    Session
    ...
End Sub

<script language="VBScript" runat="Server">
    Function GetServerGroupName()
        GetServerGroupName = cCdServerGroupName
    End Function

    Function RestoreState()
        Dim bResult
        Dim objMapX
        On Error Resume Next
        Set objMapX = GetMapEngine()
        If (StrComp(Request.ServerVariables(cRequestMethod), cPost, vbTextCompare) = 0) Then
            Dim objMapXState
            bResult = CreateMapXState()
            Set objMapXState = GetMapXState()
            objMapXState.Stream = GetHtmlFormField(cCdPreviousMapState)
            objMapXState.Restore objMapX
            bResult = DestroyMapXState()
        Else
            bResult = SetMapSize(GetMapWidth(), GetMapHeight(),
                SetMapCenterAndZoomTo(cCdefaultCenterX, cCdDefaultCenterY, cCdDefaultZoom)
                bResult = SetLayerProperties(objMapX.Layers(cCdTL), True, True, False)
                bResult = SetLayerProperties(objMapX.Layers(cCdDLHXXZ), True, True, False)
                bResult = SetLayerProperties(objMapX.Layers(cCdBJ), True, False, False)
                bResult = SetLayerProperties(objMapX.Layers(cCdHL), True, False, True)
                bResult = SetLayerProperties(objMapX.Layers(cCdCDKZXN), True, True, True)
            End If
            RestoreState = True
        End If
    End Function
</script>

Cdkznx.asp:
<script language="VBScript" runat="Server">
    Const cCdServerGroupName = "cdkzxn"
    Const cCdTL = "Railway_N"
    Const cCdDLHXXZ = "Railway redline"
    Const cCdBJ = "Border"
    Const cCdHL = "River"
    Const cCdCDKZXN = "Site type"
    Const cCdPreviousMapState = "PreviousMapState"
    Const cCdDefaultCenterX = 0
    Const cCdDefaultCenterY = 0
    Const cCdDefaultZoom = 2500
</script>

C. System introduction

There are huge quantities of available disaster prevention information in Tangshan City for system development, such as earthquake information, geologic disaster information and so on. That information shown to user is divided into different layers according to the different features of each layer by data binding of MapXtreme in the server side. Data binding is the process of bringing data from a data source into MapXtreme. For example, the distribution of site condition, include such layers: Railroad layer, Road layer, Boundary layer, River layer, and site type layer. Different site type is different to resist earthquake.

The system provides several common browse tools, include Zoom-In, Zoom-Out, Pan, which help the user change the scale and placement of the map as his will; distance measuring, by which user can measure distance between two points; information tool and the layer control. See figure 4.

Figure 4. Distribution of site type in Tangshan City
User can browse the vector map easily through mouse action, such as click, dragging and zoom. The system will display different layers according to user’s request, user can make a decision that which layer is shown and which layer is closed by the layer control. When user selects one geo-object in the map through Information Tool, system will search the corresponding attribute information from the Access2000 database, and then a window will show in which the attribute information related to the geo-object selected will be shown. The label name of the geo-object, such as road name, can be shown by adding Automatic Labels, as well as control their attributes and display.

According to user’s purposes, thematic maps can be created by GIS server, such as the distribution of basement rock fracture, shown as figure 5. The degree of basement rock fracture is represented by fracture probability.

![Figure 5. System information structure](image)

V. CONCLUSIONS

The publication information system of disaster is established based on MapXtreme according to the character of natural disaster information and Web GIS technique function, which comes from the analysis of the structure and the resolution method. System application is developed, which achieved the real-time publication of disaster prevention information in server and the real-time browse in client. System database is designed, achieved the connection between spatial and attribute data through ADO database connection and Layer bind. Therefore it can provide double-direct query between the spatial data and the attribute data.

This information system provides natural disaster information for decision-making support to deal with land use planning and management. System also can provide some basic social information service for the public through the Internet. In addition, it is an effective method for data share through Internet, which lowering the cost of the development and management. All information services and server configuration are made in the server side. User will be finding the information they want by using the IE browser conveniently. In the future, it can also extend analytic module to enhance system function through application development.

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REFERENCES


