

WEB-BASED MULTIMEDIA GIS FOR THE ANALYSIS AND VISUALIZATION OF SPATIAL ENVIRONMENTAL DATABASE

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ABSTRACT:

Recently, Web-based GIS applications have become important tools for disseminating geographical information in digital map format on the Internet because of their platform independence, interactivity, and wide accessibility. This trend brings about new insights on the integration of Web-based GIS and multimedia on the Internet since multimedia has already been seen as the strength of Internet applications.

This paper briefly examines the principles of Web-based GIS applications and multimedia technology, and then focuses on the development of a Web-based multimedia GIS that links GIS and multimedia technologies on the Internet. The Web-based multimedia GIS is based upon interactions between three components: 1) a Web-based GIS application developed to manipulate spatial environmental database including georeferenced images and digital maps; 2) a Web-based interactive multimedia application designed to manipulate multimedia information including text, graphics, photographs, digital video and sound; and 3) a mechanism of linking the Web-based GIS application and the Web-based interactive multimedia application. The paper concludes with an example that demonstrates the use of a Web-based multimedia GIS, which allows the user to explore digital maps and associated multimedia information on the Internet.

1. INTRODUCTION

Recently, there has been new trend in developing Web-based GIS applications. Researchers in this field have recognized Web-based GIS applications are becoming an important tool to disseminate geographical information on the Internet because of their platform independence, interactivity, and wide accessibility. Those applications can be generally categorized into two types: (1) to allow various end-users to access spatial database and conduct simple spatial analysis (Peng and Nebert, 1997; Abel et al., 1998; Sadagopan et al., 2000); and (2) to allow end-users to perform sophisticated spatial analysis for decision-making (Peterson 1997; Doyle et al. 1998, Peng 1999, Dragicevic et al. 2000; Meyer et al. 2001; Zhang and Wang 2001).

Web-based GIS applications are based upon the interactions between client and server computer systems through network technology (Figure 1). The client side allows Internet users to access remote computers on the Internet by providing request through standard Web browser software such as Microsoft Internet Explorer, Netscape Navigator, or other custom-generated software such as Environmental System Research Institute (ESRI) ArcExplorer.

The network technology provides Internet software components that communicate with each other on various computers connected by the network. Those components include HTTP (i.e., hypertext transfer protocol), and TCP/IP (transmission control protocol / Internet protocol). Protocols are the language that makes Internet communication possible.

The advancement of computer technology enables the integration of GIS and multimedia technologies, called multimedia GIS, that allows to incorporate not only spatial and/or temporal geographic information in image/vector format but also multimedia geographic information in descriptive text, scanned ground photographs, graphics, digital sound and video (Hu, 1999; Hu, et al., 2000; Hu, 2001; Hu, 2002a; Hu 2002b).

The development of GIS database for environmental management often generates not only digital data sets in vector/image format, but also multimedia information in 1) text (descriptive text, narrative and labels); 2) graphics (drawings, diagrams, charts, snapshots or photographs); 3) digital video (television-style material in digital format); 4) digital audio sound (music and oral narration); and 5) computer animation (changing maps, objects and images). It is challenging to bring data sets in various formats into a coherent computer system that allows end-users such as policy maker, resource manager and the public with different computer skills to analyze and visualize them.

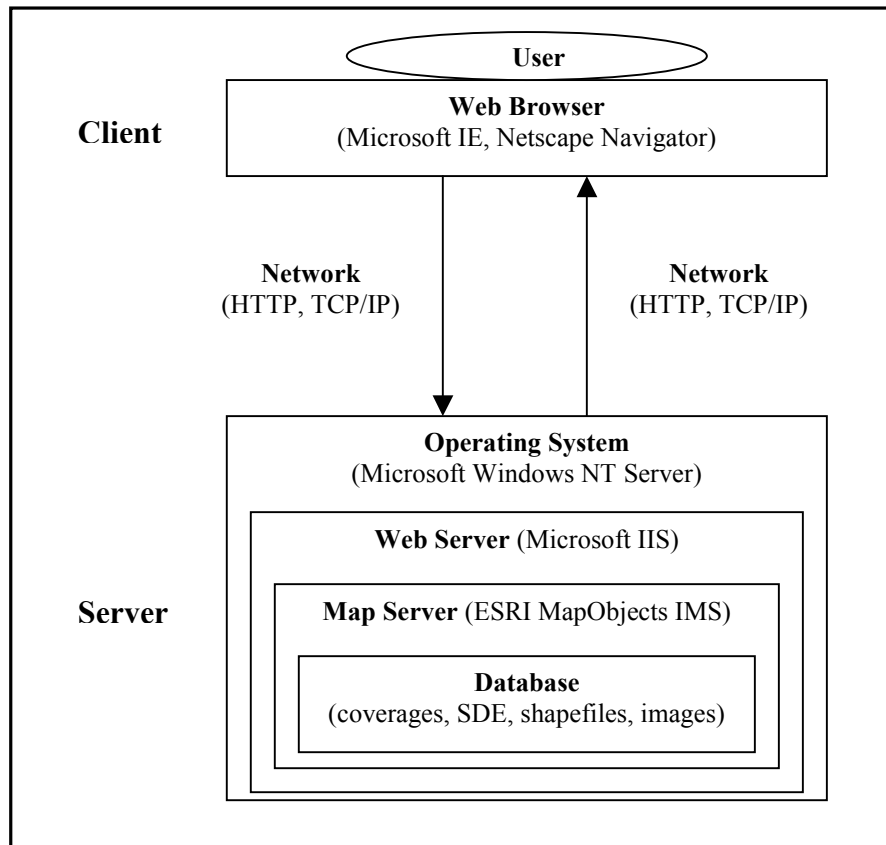


Figure 1. Web-Based GIS application architecture

2. RESEARCH OBJECTIVE

The objective of this research is to develop a Web-based multimedia GIS approach that: 1) is interfaced with GIS for the analysis and visualization of spatial GIS database in vector/image format; 2) permits the combination of GIS database with multimedia information 3) allow the user to access the databases via standard Internet explorer such as Microsoft Internet Explorer or Netscape Navigator.

The study area is corresponding to the U.S. Geographical Survey (USGS) Long Pine Key and Pa-Hay-Okee Lookout Tower 1:24,000-scale topographic quadrangles in Everglades National Park (Figure 2). A GIS database includes detailed vegetation maps, and scanned National Aerial Photography Program (NAPP) 1:40,000-scale color-infrared (CIR) aerial photographs, which are the data source for the development of digital vegetation maps. The multimedia database contains descriptive text, ground photographs, digital video clips and audio segments highlighting the characteristics of Everglades natural environment (i.e., climate, landform and hydrography) vegetation plant communities, individual species, and invasive exotics, as well as plant-animal interactions, hurricane damage, and post-fire vegetation succession.

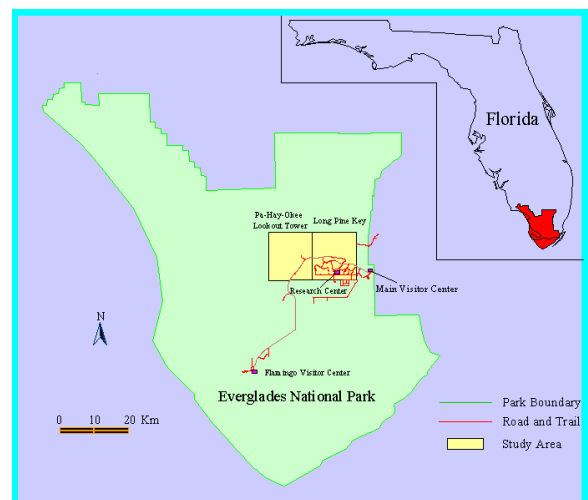


Figure 2. Study area: Long Pine Key (right) and Pa-Hay-Lookout Tower (left) quadrangles in Everglades National Park.

3. METHODOLOGY

The web-based multimedia GIS approach was based upon interactions between three components: 1) a web-based GIS application developed using Microsoft Visual Basic 6.0 and Environmental Systems Research Institute (ESRI) MapObjects Internet Map Server software to manipulate spatial data sets in ArcView shapefiles of vegetation patterns, and geographically referenced CIR aerial photographs; 2) a web-based interactive multimedia application created using hypertext markup language (HTML) and designed to manipulate multimedia information such as hypertext, hyperlinks, ground photographs, digital video, and sound; and 3) a mechanism of linking the Web-based GIS application and the Web-based interactive multimedia application. All three components were developed on a Compaq network server with 1.4 GHz microprocessor, and 256 megabytes RAM, running Windows NT Network Server operating system. Microsoft Internet Information Server (IIS) was employed as Web server and ESRI MapObjects Internet Map Server 2.0 as map server.

Visual Basic is a state-of-the-art rapid application development (RAD) programming environment that combines an interactive design tool and an object-oriented programming language (Microsoft, 1999). In this environment, extended capabilities can be added to the standard Visual Basic through the use of ActiveX custom controls (i.e., software components). This feature also permits companies to offer components with specific functionality tailored to applications such as GIS. Map control, toolbar control, and status bar control were used to develop the GIS application and graphical user interface, whereas text control, picture control, time control, and scroll bar control were used to develop the interactive multimedia system. The underlying relation among various custom controls was manipulated using Basic language. The following sections discuss the development of the three components mentioned above.

MapObjects is ESRI's professional library of mapping and GIS software components for embedding spatial visualization and analysis in custom-written GIS applications. MapObjects includes an ActiveX custom control and a collection of over 35 programmable OLE (i.e. object linking and embedding) automation objects that let developers add mapping and GIS capabilities to applications developed within an application development environment such as Visual Basic (ESRI, 1996).

MapObjects was utilized in Visual Basic as an ActiveX map control, and then image/vector data tied to a geographic coordination system are able to be added to the map control at the design time by writing Basic code. Plate 1 is an illustration of the Web-based GIS application (URL: <http://gis.uwosh.edu/scripts/esrimap.dll?name=everglade&cmd=map>). GIS functions such as Zoom, Pan, and Identify were developed to manipulate the image/vector GIS database. For instance, the user can select the "Zoom in" option, and zoom into an area on the digital map, then select the "Identify" option, click on any polygon, and the alphabetic letters representing the dominant vegetation category in that polygon will be displayed on the screen (Plate 2). Furthermore, the user can select "Hyperlink" option and click on one polygon, he/she will be directed to a ground panoramic view of that plant community, followed by a interactive multimedia application containing

multimedia information and including hypertext and hyperlinks, about the plant community (Plates 3).

The development of an interactive multimedia application utilized the concepts of hypertext and hyperlinks on World Wide Web (WWW), which can provide interactivity and non-linear information retrieval. A hypertext, displayed in blue and underlined, was constructed to allow interactive access to multimedia information in the form of descriptive text, ground photographs, digital video, and sound. There are numerous ways to design excellent Web-based interactive multimedia applications for use on the Internet. Commercial software includes HTML, Macromedia Director and Dreamweaver, and Adobe Streaming Media Collection, to name just a few.

4. CONCLUSIONS

The main purpose of this study was to provide the user with user-friendly tools to visualize both spatial data and associated multimedia information on the Internet. Everglades National Park was selected as a test area for this study. The development of the new approach to linking spatial database with multimedia information demonstrated the strength of Web-based multimedia GIS technology and its potential for applications in environmental management, urban planning, and tourism. Agencies and organizations who task developing GIS databases, especially applications in natural resource management, can employ this technique to disseminate the various types of collected information to end users (i.e. resource managers, planners, and the public) with different levels of computer skill. Further research will focus on incorporating more GIS analytical functions and modeling capability.

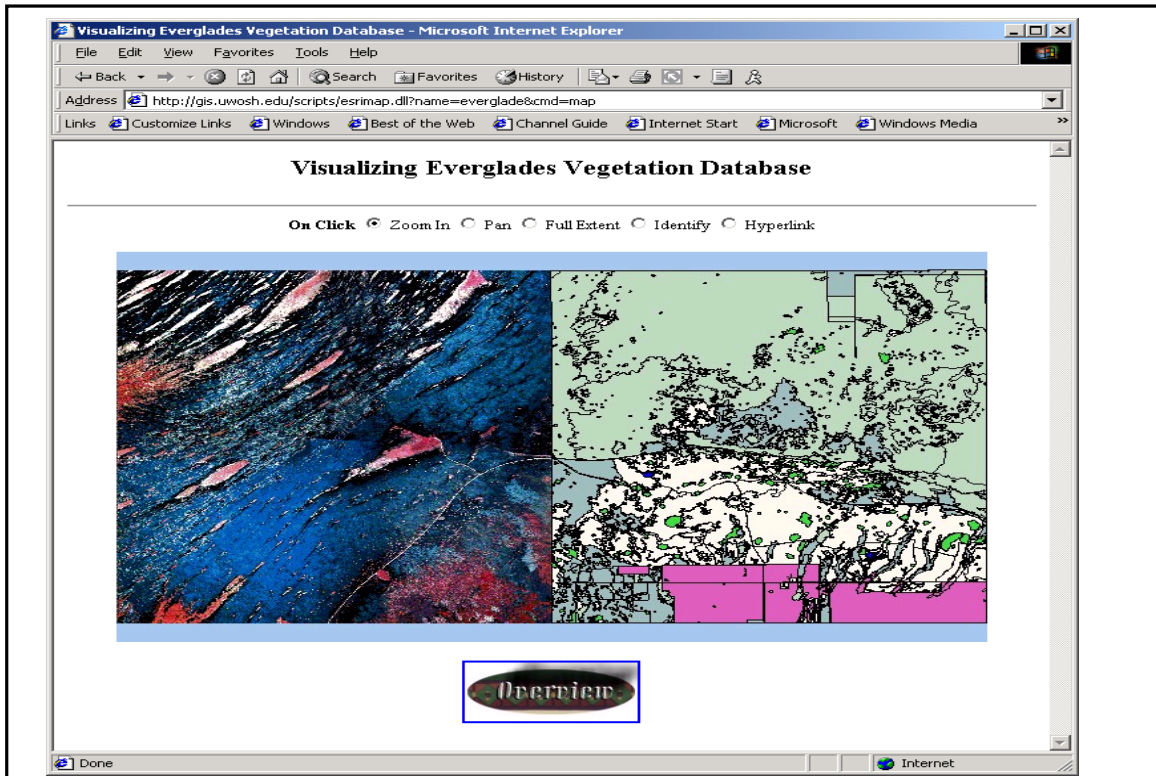


Plate 1. The Web-based GIS application for visualizing spatial database: NAPP CIR aerial photographs for Pa-Hay-Okee Lookout Tower (left) and digital vegetation map for Long Pine Key (right) in Everglades National Park.

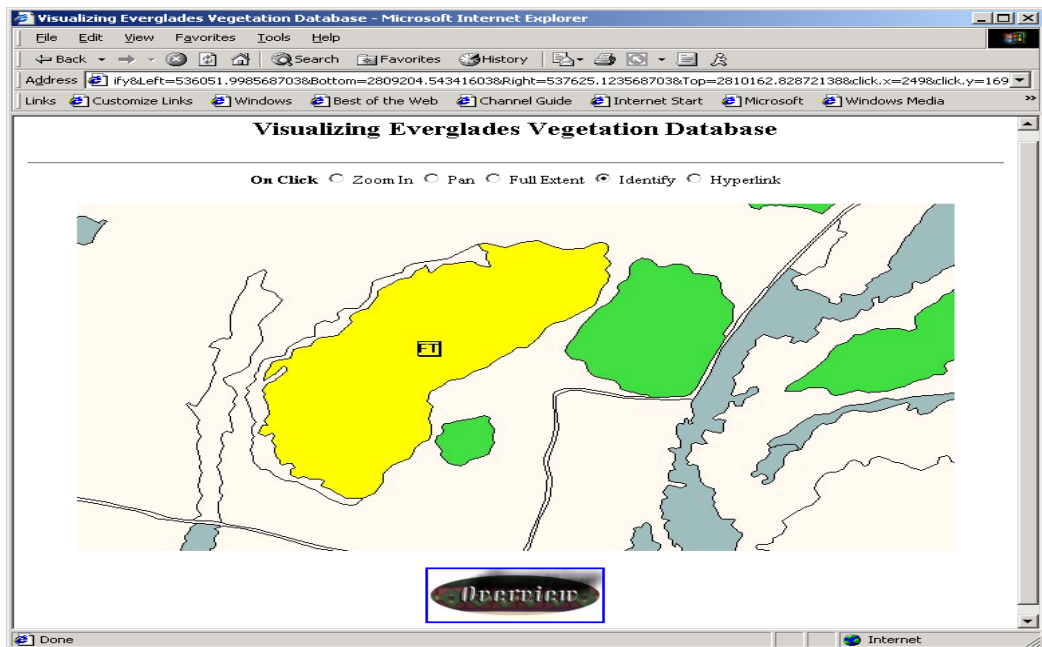


Plate 2. The Web-based GIS functions allow the user to manipulate spatial data sets, and to retrieve the dominant vegetation category for a selected polygon from the GIS database.

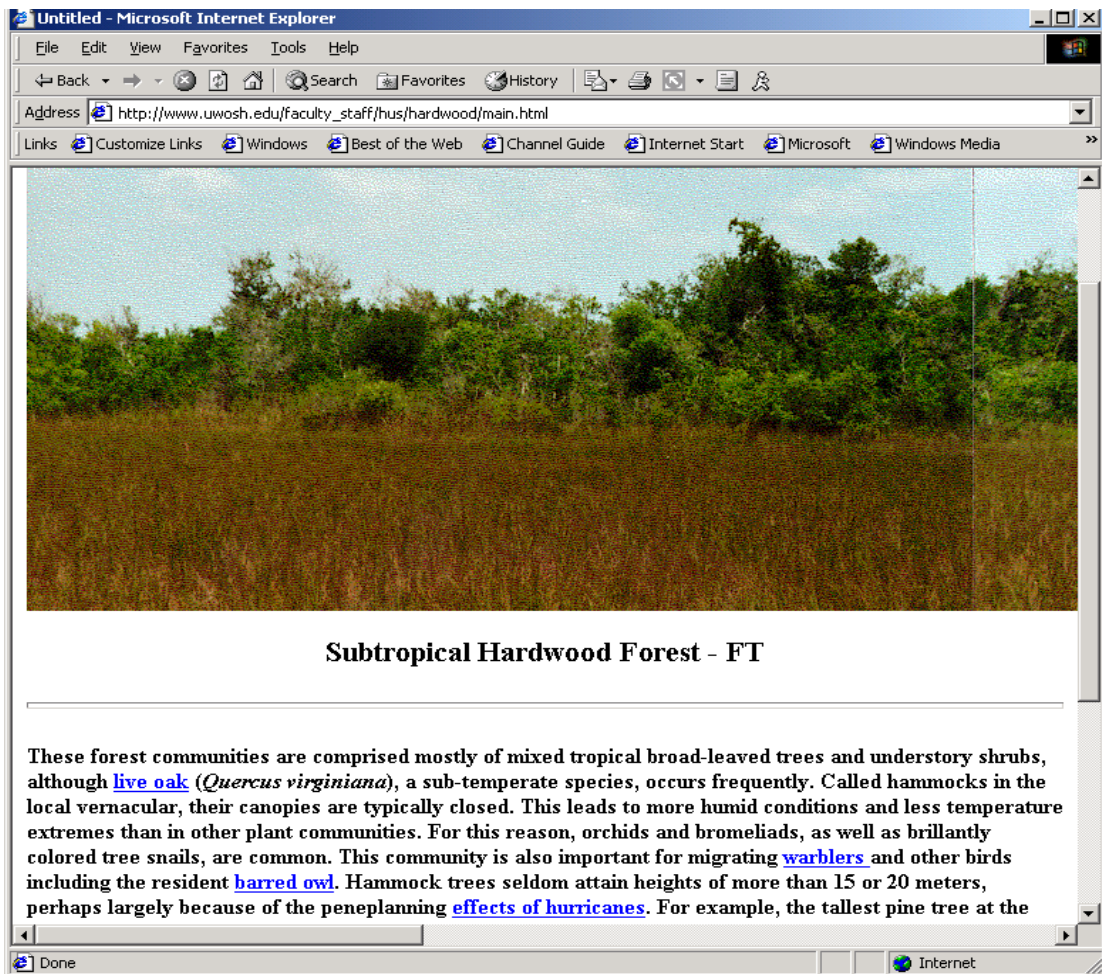


Plate 3. A Web-based interactive multimedia application provides hypertext and hyperlinks to explore multimedia information (ground photographs, text, etc.) about the Everglades natural environment.

REFERENCES

- Abel, D., T. Kerry, R. Ackland and S. Hungerford. 1998. An Exploration of GIS Architectures for Internet Environments, *Computer, Environment and Urban Systems*, 22(1): 7-23.
- Bill, R. 1994. Multimedia GIS – Definition, Requirements and Applications, *European GIS Yearbook*, Blackwell, Oxford, pp. 151-154
- Doyle, S., M. Dodge and A. Smith. 1998. The potential of web-based mapping and virtual reality technologies for modeling urban environments, *Computer, Environment, and Urban Systems*, 22(2): 37-55.
- Dragicevic, S., Balram, S., Lewis, J. 2000. The role of Web GIS tools in the environmental modeling and decision-making process. *4th International Conference on Integrating GIS and Environmental Modeling(GIS/EM4): Problems, Prospects and Research Needs*. Banff, Alberta, Canada, September 2 - 8, 2000, <http://www.colorado.edu/research/cires/banff/upload/363/>
- ESRI (Environmental System Research Institute). 1996. *MapObjects - GIS and Mapping Components*, ESRI: Redlands, California, 202 p.
- Hu, S. 1999. Integrated multimedia approach to the utilization of an Everglades vegetation database, *Photogrammetric Engineering and Remote Sensing*, 65(2), 193-198.
- Hu, S., A. O. Gabriel, and C. Lancaster. 2000. An integrated multimedia approach for wetland management and planning of Terrell's Island, Winnebago Pool Lakes, Wisconsin, *The Wisconsin Geographer*, 15-16, 34-44.
- Hu, S. 2001. Multimedia GIS: analysis and visualization of spatio-temporal geographic information, *International Achieves of Photogrammetry and Remote Sensing*, Vol. 34, Part 4/W5, pp. 42-47
- Hu, S., 2002a. Inventory and characteristics of wetland habitat on the Winnebago Upper Pool Lakes, Wisconsin: an integrated multimedia GIS approach, *Wetland*, forthcoming.
- Hu, S. 2002b. Multimedia GIS: analysis and visualization of spatio-temporal and multimedia geographic information, *ISPRS Journal of Photogrammetry and Remote Sensing*, forthcoming.
- Meyer, J., R. Sugumaran, J. Davis and C. Fulcher. 2001. Development of a web-based watershed level environmental sensitivity screen tool for local planning using multi-criteria evaluation. In: *Proceedings of ASPRS Annual Conference*, April 23-27, St. Louis, MO.
- Microsoft. 1999. *Microsoft Visual Basic: Programmer's Guide*. Microsoft Cooperation: Seattle, Washington, 898 p.
- Nielson, J. 1990. *Hypertext and Hypermedia*, Academic Press Professional, Boston, Massachusetts, 296 p.
- Peng, Z. and D. Nebert. 1997. An Internet-Based GIS Data Access System, *Journal of the Urban and Regional Information Systems Association*, 9(1): 20-30.
- Peng, Z. R. 1999. An assessment framework for the development of Internet GIS. *Environment and Planning B: Planning and Design*, 26:117-132.
- Peterson, M. 1997. Trends in Internet Map Use. In: *Proceedings of 18th International Cartographic Conference*, ICA Stockholm, Sweden, pp.1635-1642.
- Sadagopan, G., J. J. Richardson and R. Singh. 2000. Complying with the freedom of information act, *Geo Info System*, 10(1):28-32.
- Zhang, X. and Y. Q. Wang. 2001. Web based spatial decision support for ecosystem management. In: *Proceedings of ASPRS Annual Conference*, April 23-27, St. Louis, MO.
- Zhang, Z., J. Tsou and H. Lin. 2001. Virtual collaboration on visual impact assessment: a web GIS approach. In: *Proceedings of ASPRS Annual Conference*, April 23-27, St. Louis, MO.