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CAPABILITIES OF MULTIMEDIA GIS

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ABSTRACT: A geographical information system (GIS) is used to capture, store, retrieve, analyzed and display the spatial (locationally defined) data. In contrast to traditional GIS, multimedia GIS is not only able to collect, analyze and store the data in traditional formats i.e. text, images (pictures) and graphs but also audio (sound), animations and video (moving pictures) as well. In this paper the advantages of multimedia GIS over traditional GIS are explained. Multimedia GIS is fully capable of providing services to both technical and non-technical users and users of multimedia GIS can retain more knowledge than users of traditional GIS. It can be applied to various fields such as tourism, environment, education etc. Some implementation issues such as data updating, information retrieval and data compression etc. are also addressed. Finally, future development of MMGIS (using new multimedia technologies such as Virtual Reality and Virtual Reality Modeling Language) is discussed.

KEY WORDS: GIS, multimedia GIS, multimedia database, virtual reality, virtual reality modeling language

The phrase Multimedia GIS (MMGIS) is a combination of two terms multimedia and GIS. The term multimedia (MM) is defined as "A multimedia system is characterized by computer-controlled, integrated production, manipulation, presentation, storage and communication of independent information, which is encoded at least through a continuous (time-dependent) and discrete (time-independent) medium"(Steinmetz, 1995). The term GIS is not easy to define in few words. A definition of the term GIS by NCGIA (National Centre for Geographical Information and Analysis) is "A geographical information system (GIS) is a computerized database management system for capture, storage, retrieval, analysis, and display of spatial (locationally defined) data" (Garni, 1996). There are also several ways to define Multimedia GIS such as "Multimedia GIS is the combination of the use of GIS to georeference, structure and analyze these data and the creation of multimedia presentations with links to spatial features" (Moreno-Sanchez *et al.*, 1998). Or a definition by Laurini and Thompson as "Multimedia GIS is a variety of analogue and digital forms of data that come together via a common channel of communication" (Parsons, 1995). Simply, the term Multimedia GIS can be defined as that which is capable of capturing, storing, retrieving, analyzing and displaying geographically referenced multimedia data.

Integration of Multimedia and GIS is a new area. There are two ways to view integration of multimedia and GIS (Moreno-Sanchez *et al.*, 1998; Soomro *et al.*, 1998). (1) "GIS in Multimedia": this approach uses multimedia-authoring tools to blend different data types (text, image, video, audio) and spatial analytical function to boost traditional GIS or in other words MM has capabilities to incorporate GIS. Web GIS (GIS found on Web with power of Web) is the best example of GIS in Multimedia. Web is a distributed hypertext multimedia information service, which enables GIS to equip multimedia facilities. (2) "Multimedia in GIS". In this approach the traditional GIS will encompass the capabilities to take care of multimedia or in other words GIS has capabilities to incorporate MM data types.

The next section of this paper covers MM data types, MM databases, and MMGIS. Then MMGIS and traditional GIS comparison with advantages of MMGIS over traditional GIS are also covered. Applications of MMGIS in various fields and implementation issues of MMGIS data are discussed. Finally, future development of MMGIS (using new multimedia technologies such as Virtual Reality and Virtual Reality Modeling Language) is discussed.

2 MULTIMEDIA DATA, MM DATABASE AND MMGIS

Methods of data gathering have been developed throughout history. From past to present spatial data have been gathered, analyzed and displayed in analog form to digital form. Now simple digital form called multimedia form is very popular and widely used.

2.1 Multimedia Data

Over the last two decade, the management of multimedia data in database environment has evolved through the following sequences of conceptual and performance insights: (1) Multimedia data was first transformed into relations in an ad-hoc way. Simple type of queries and operations were supported. (2) What kind of information should be extracted from images and video? (Complex queries and operations) and how this information should be represented to support content-based queries most efficiently? The result was a large body of work on multimedia data models. (3) Data models specified the types of information that could be extracted from multimedia data; the nature of multimedia queries was also discussed. (4) A multimedia query was seen as quite different from a standard database query and close to queries in an information retrieval setting.

Multimedia data contains text (alphanumeric), graphics, images, audio and video (animation) and is quite different from standard alphanumeric data in terms of both presentation and semantics. From a presentation point of view, multimedia data require huge amount of storage and fast access to data. In all cases data in a digital form require extensive computer storage, and processing power. Because of its complex structure, multimedia data requires complex processing to derive semantics from its contents.

In standard database systems, a data model is a collection of abstract concepts that can be used to represent real-world objects, their properties, their relationship to each other, and the operations defined over them. What makes a multimedia data model different form a traditional data model is that multimedia objects are completely defined in the database and contain references to other real-world objects that should also be represented by the data model. For images, the structure should include such things as the image format, the image resolution, the number of bits per pixel, and any compression information; for a video object, such items as duration, frame resolution, number of bits per pixel, color model, and compression information are included.

Presently multimedia technology is popular and widely used by technical and non-technical users to represent spatial data. Following are the media.

2.2 Text

Text is generally the easiest way to represent data. In case of GIS in Multimedia (e.g. Web GIS), HTML (Hyper Text Markup Language) help to view the text in variety of forms such as providing different fonts, and their different sizes, different color schemes with text alignments and formatting and so on. Some browsers (e.g. Internet Explorer) allow you to view scrolling Marquees (e.g. < MARQUEE > TEXT < MARQUEE>).

2.3 Images

Images are one of the simplest forms of visualization using multimedia data, either produced by scanning existing photographs, or captured, directly from videotapes etc. HTML helps to view basic images; background images, and also allows viewing the maps

as ismap for Server-Side Maps and usemap for Client-Side Maps. HTML allows Common Gateway Interface (CGI) to incorporate image maps. CGI Scripts can be used to handle input from image maps. This input is different from the input that an HTML form sends. With the help of CGI, static and dynamic map can be handled. Handling static data is usually easier because the meaning of the user's selection can be determined early in the decoding process. Dynamic maps require the user's selection to be interpreted late.

Image maps allow different regions of an image to be mapped into different URLs (Uniform Resource Locators) that are retrieved when the region is clicked on. Thest URLs can be for an HTML document, an image, a CGI Script, or anything else that can be referenced from the Web.

Dynamic image maps or images in general can be defined as clickable images so that they return the user's chosen coordinates (x, y) to any CGI Script. These images do not need to create a map file but must have a script that is able to handle the coordinates and process the request (Stephen *et al.*, 1998).

2.4 Audio

Audio was the first step towards today's multimedia capabilities. Now sound and music are common addition to MM tools and MMGIS applications to help simulate reality. Some electronic atlases use sound (music) and video to enhance their graphics. Encarta World Atlas, Virtual Globe, Map of China and Compton's 3-D Atlas are examples of MM software. HTML helps to listen sound (sometimes in the form of oral presentation) background sound and music. An HTML standard allows two ways to incorporate multimedia contents. The first approach is Java and other approach is indirectly supported by HTML through its < IMG> tag. Jave is a programming language that provides methods for integrating graphics and sound into synchronize displays, complete with the capability for user interaction. Jave Animator Applets can be used to add animation and sound to any kind of Web page. Currently Java support. AU file format, other files format can be converted by using audio format conversion utilities. HTML support < APPLET> tag to include Java Applets. The basic syntax to include Java Applet is:

< APPLET> code= "appletName. CLASS" width = "wPixels" high= "hPixels" > < /APPLET>

2.5 Video

Videos and animation are the more complex form of visualization. This form of representation offers considerable advantages in terms of providing sense of place. Video offers tremendous potential to draw a viewer into a virtual world. HTML helps to view video clips and animations as we mentioned in the above subsection by using Java and HTML's < IMG> tag.

2.6 MM Database

Conceptually there are two ways to view MM database. One way is to include all media as an integral part of a single database (e. g. Oracle etc.). Other way is to include all media as a sub-database, connected in such a way to achieve communication among them. MM database consists of following sub-databases(Georgia *et al.*, 1994; Soomro *et al.*, 1998). (1) Text Database: may contain text in the form of messages, comments and definitions etc., as required by the user need. Sometimes text in the form of oral presentation with the help of audio database may be included. (2) Image Database: may contain all the images, maps, sketches, graphics, photos, etc. combined with the text, audio etc., where necessary. (3) Audio Database: may constitute all the sound signals, oral presentation (of text) and music. (4) Video Database: may contain animation and full motion videos along with sound and music as per requirement. All these media will improve the presentation atmosphere. e. Main Database: is the central database of the system that is capable of connecting all other sub-databases. Main database contains all the information available for users. Every

query, insertion, updation and deletion is performed by this database.

2.7 MMGIS

Multimedia GIS can be defined as that which is capable of capturing, storing, retrieving, analyzing and displaying geographically referenced multimedia data and is the combination of all MM data types and other geographically referenced information. Conceptually MMGIS can be divided into three layers (Fig. 1). The top layer called MMGIS, is capable of interacting with MM database to display, record and analyze the desired spatial data and to provide required

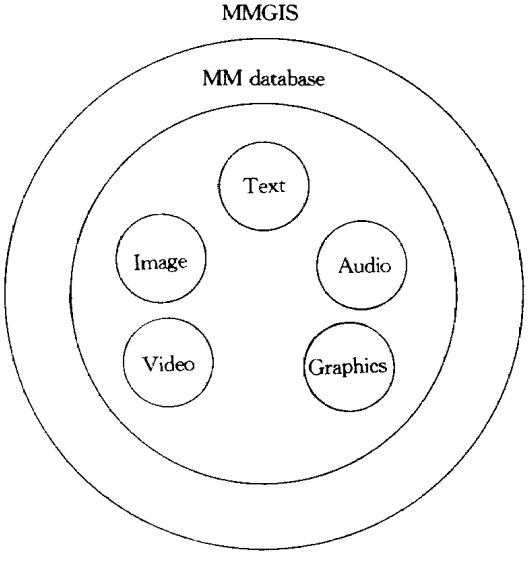

Fig. 1 The three layers of MMGIS

output. The middle layer is called MM database, which is capable of interacting with the bottom layer's sub-databases. It is MM database's responsibility to communicate between user and bottom layer's sub-databases. It is MM database's responsibility to communicate between user and bottom layer's sub-databases. Bottom layer (not visible to users) contains the MM sub-databases, text database, image database, audio database, and video database. All these sub-databases are interconnected with each other.

3 MULTIMEDIA GIS VS TRADITIONAL GIS

Information sources like topographic maps, field measurements, Global Position Satellite (GPS) data and satellite and other airborne scanners are used to develop and update the topographic data (Camara, 1996). Traditional GIS software works with numerical data and structured text. On the other hand MMGIS stores binary data, for example images unformatted text, audio, video and all traditional data types. Using MMGIS data can be both time-dependant (in case of animation and audio) and time-independent (in case of text and images).

Users of traditional GIS include public and private institutions in a variety of fields (McGlamery *et al.*, 1994; Camara, 1996). On the other hand, future users of the less precise multimedia (and virtual reality) GIS will be primarily individuals, depending on their requirements of the system for a particular task (McComb, 1994).

One of the differences between MM and traditional GIS is in the data formats. The following are the most common MM data formats of which traditional GIS support only few. (1) Audio: .WAV, .AU, .CDA, .MP3, .MMP, .M3U etc. (2) Video: MPEG (.MPG), .AVI, .MOV, .DAT, .VBS, .MPA, .MPV etc. (3) Image: JPEG (.JPG), .GIF, .TIF, .BMP, .PCX, etc.

MMGIS has the ability to incorporate the MM data formats along with traditional GIS formats, but traditional GIS has no ability to incorporate the above autdio and video formats①.

4 ADVANTAGES OF MULTIMEDIA GIS

(1) MMGIS has full capability to provide services to both technical and non-technical users.

(2) MM provides such an atmosphere in which user feels comfortable with the system environment before addressing the issues of data analysis. Basically MMGIS allowuser to interact with datasets and help

① Parsley Scott, 1997. A Three Dimensional, Multimedia, Geographical Information System Across Internet.

to increase his/her understanding of these datasets.

(3) Users of the MMGIS will retain more knowledge than users of traditional GIS. The combination of several media often results in powerful and richer presentation of information & ideas to stimulate and enhance information retention.

(4) MMGIS allow traditional data in the electronic or digital formats and also allow updating the data easily and efficiently with low cost①.

(5) MMGIS is also capable of improving procedures for data collection, accuracy & management of temporal data, and understanding of the computerized tools used to handle uncertainty in digital spatial database②.

The combination of audio and video along with traditional data types can improve the performance of GIS tuning it into a more realistic tool for spatial analysis. Video can be used to show background, point scenes, or transition and audio to provide realism by communicating the notion of space. This will allow more clear and transparent view of overall situation and better understanding of its spatio-temporal implications, as a result of accessing additional source of information. Video & sound can be used within GIS in different contexts: For illustration purposes (to show backgrounds, point scenes or transitions); provide the notion of space (clear the conception); visualization of some GIS operation; to support the definition of criteria (to be used in spatial analysis); to support the implementation of models within GIS; to help in the evaluation of some GIS results; to create movement or illustrate point scenes; and a source of information, namely for simulation models

MMGIS can possibly create multiple representation for same phenomena. This characteristic enables the users to view same information in several different contexts (Fonseca *et al.*, 1994).

5 APPLICATIONS OF MULTIMEDIA GIS

Multimedia GIS can be applied to various fields such as tourism, environment, training & education and agriculture & forestry etc.

5.1 Tourism

Tourism is the field in which MMGIS is most successfully implemented. The best example is the "Tourist Information System for the county of ATTICA". This system is basically used as a tourist guide for museums, archaeological and historic sites and monuments that lie in Attica. MAGIC TOUR (Multi-media and geographical information system based tourism applications authoring system and MAGIC TOUR NET (Multi-media and geographical information based tourism application authoring system are two more examples of MMGIS in tourism (Georgia *et al.*, 1994; Nahle, 1997).

5.2 Environment

Issues like environmental negotiation, administration and monitoring are important. At the regional level performing these activities requires the assembling, management, analysis and presentation of large amounts of georeferenced information from different sources (e.g. digital sources like digitized maps, remote sensing, airborne videography, video, aerial photographs, and statistical archives), formats and scales. A modular approach of MMGIS was used to support environmental negotiation, administration and monitoring at the regional level by Rafacel and others (Moreno-Sanchez *et al.*, 1998). Monitoring the coastal environment or marine environment is another application of MMGIS (Raper *et al.*, 1994; Kvitek, 1998). MMGIS is used for Environment Impact Assessment (EIA), which is a decision process that aims both to identify and anticipate the impact on the natural environment, human health and quality of life (Fonseca *et al.*, 1994). Ecology & Zoology require an abundant knowledge of the envi-

① Salah Benabdallah, Karima Bounemra Ben Soltane, 1996. The importance of Multimedia and Geographical Information System technologies in the tourism industry.

② Giodano A., K. Rybaczuk *et al.*, 1998. A Handbook and multimedia support tool to aid the assessment of data quality issues in GIS database.

ronment at both large and small scale in order to build up a picture of the natural habitat. MMGIS is also useful in these fields①.

5.3 Training & Education

There are basically two ways to teach, one is direct method in which teachers, instructors, or presenters deliver their lectures to students or viewers and indirect way in which teachers, instructors, or presenters use some other tools or media to present their lectures. These tools are in the form of pictures, maps photographs, etc. In this digital era they are in the form of multimedia. Using MMGIS in training, the cost of training the staff will be reduced and learning time will be shortened. Of course, MMGIS systems will not replace the teachers, instructors, and presenters. They will just make them concentrate on explaining facts and processes instead of conveying them (Nowicki *et al.*, 1996). Thus, MMGIS captures a market that has little or no knowledge of computers or geographical information①. ENVIDUCATION (Multimedia GIS for elementary Environmental Education) is the MMGIS package for elementary environmental education that is available in the market.

5.4 Agriculture, Forestry & other fields

Agriculture and forestry are the new fields for implementing MMGIS (Nowicki *et al.*, 1996). There are many other fields in which MMGIS plays an important role. Urban Information System is one of the examples of MMGIS implementation in the field of urban planning and development.

6 MMGIS IMPLEMENTATION ISSUES

There are many MMGIS implementation issues e.g. updating, retrieval and compression etc. Update procedures should be developed before implementation. Updation of MM data is some how different from traditional GIS data. Images, audio and video require more updating than the traditional data, simply because of huge quantity of storage and extensive computational power (McComb, 1994).

To display, retrieve and save the image, video and audio signals (on some storage location or from one location to other) requires more software capabilities and hardware speed and storage. To achieve this goal compression of multimedia data types is needed. To save a huge amount of map requires space and speed. With the help of compression, user can reduce the image, resolution, the number of color displayed (bit depth). For example, Standard software for Joint Picture Expert Group (JPEG) can compress images at a ratio of about 20:1, with no noticeable loss of quality (Hughes, 1996).

7. DISCUSSION

Future technologies like Virtual Reality and Virtual Reality Modeling Language (VRML) play a key role in incorporating MM with GIS. VRML enables user to view MM data remotely via Web. It is now possible to transmit multimedia data types across the Web, although the quality depends on Internet connection, capacity and speed of computer hardware and capabilities of computer software.

7.1 Virtual Reality

Historically, GIS was born in two-dimensions in the form of paper mapping. Early systems were capable of digitally displaying the 2-D maps (an equivalent of paper map). After new developments and inventions many tools now exist to display "true" 3-D data example is Virtual Reality (VR). VR used "immersion" technology, which provides 3-D graphics and computer interface devices which closely resemble the user's normal interface to the physical world. Virtual reality tries to convince the user that they are actually in another environment, by replacing the normal see-

① Parsley Scott. 1997. A Three Dimensional, Multimedia, Geographical Information System Aross Internent.

tary input received by the user with information from virtual environment. Here it is important to understand that VR is not the model, but a tool to view that model. Virtual reality is mainly used in the design and viewing of 3-dimensional models, however it is also feasible to display two-dimensional model. Virtual reality gives user the ability and control to view the model from any position they like (Parsons, 1995; Soomro *et al.*, 1998).

7.2 Virtual Reality Modeling Language & Virtual Reality Transfer Protocol

Currently Web with HTML provides a two-dimensional interface to the information it contains. In HTML 'M' stands for Markup, but in Virtual Reality Modeling Language it stands for Modeling, to distinguish the nature of both languages. VRML was invented around 1994 following the WWW Conference in Geneva. There is still a long way to go towards full virtual reality across the Internet. Like HTML it is necessary to have capable browser to view VRML files (e.g. CyberPassage from Sony) ①. As HTML needs a protocol called Hyper Text Transfer Protocol (HTTP) to access the VR data across the Web. No doubt we can predict that the next generation of Internet will use the VRTP instead of HTTP and VRML instead of HTML, to view the 3-D multimedia virtual environment.

With the help of systems capable of quickly and easily mixing text, images, graphics, sound and video on one hand and Virtual Reality environment to view 3-D world and integration of Web techniques on the other hand, will enhance the capabilities of GIS systems, and users of GIS can begin to meet the requirement of 21st century communication.

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