Haklay, M., 1998, *A Survey of Current Trends in Incorporating Virtual Reality and GIS*, in Proceedings of GIS Research UK 1998, Edinburgh, UK, 1-2 April. pp. 10-6 - 10-9

A Survey of Current trends in incorporating Virtual Reality and Geographical Information Systems

Extended Abstract

M.Haklay
Centre for Advance Spatial Analysis
University College London
1-19 Torrington place, London WC1E 6BT, UK
Tel: +44 171 391 1255, Fax: +44 171 813 2843
Email: m.haklay@ucl.ac.uk

Abstract

The paper describes the results of a comprehensive literature and Internet survey on current trends in virtual Reality GIS (VRGIS). In the first part of the paper, a background of VRGIS is set, followed by the description and classification of the main research areas which focus in VRGIS research with an attempt to clarify the reasons that led the researchers to pursue a VR solution for the specific problems in their research field.

Based on the observations from the current practice, the main definitions of VRGIS are discussed in the third section. Finally, future directions and possibilities for development are drawn.

Introduction

In the last few years, research projects that merge Geographical Information Systems (GIS) with Virtual Reality (VR) systems gain more and more popularity. Several recent developments in computing can be seen as the base for this trend: the widespread use of powerful desktop computers (Hughes,1996), the re-evaluation of VR as a simulation of reality rather than imitation of it (Gillings & Goodrick,1996) and the rise of the VRML standard coupled with a wide range of tools that accompany it. By now, it's possible to locate and classify the research area that focus on applications VRGIS and to envisage the future direction of this field. Throughout this paper, the term VRGIS (Virtual Reality GIS) will be used to refer to those systems. Though it must be stated that this term incorporates a wide range of applications - ranging from non-immersive, low end computing implementations to supercomputer based, highly immersive applications. Nevertheless, it is possible to find common properties and attributes to all those VRGIS systems. This paper will try to locate and state them.

The current paper is based on an Internet survey from November 1997 and a follow up questionnaire that was sent at the beginning of January 1998, to all the centres with relevant projects in this field. The Internet survey was based on Web pages, reports in USNET groups and printed literature on the progress in combining GIS and VR.

A short history of VRGIS

Although the roots of both GIS and VR can be easily traced back into the 70's, the first documented successful fusion of GIS and VR was done in the early 90's with a system that depict the Georgia Tech campus area (Faust,1995). Since then, the number of application and research projects that involve VR and GIS have increased dramatically. The first wave of VRGIS application was based on high end workstations and even supercomputers due to the intensive computation nature of both fields - e.g. the geometrical computation in GIS and heavy rendering computation in VR (Faust,1995).

From the mid 1990s, a re-evaluation of VR lead to a major change in the research agenda. The result was that VR is not seen as a method for *imitate* reality but rather to *simulate* aspects of it as a sensual form of communication (Gillings & Goodrick,1996). This change paved the way to the next major development - VRML (Virtual Reality Macro Language). VRML emerged from 1995 onwards (Bell *et al.*,1996) and opened a new direction for the development of VRGIS. By using VRML, the economics of deploying a VRGIS dropped enormously. This development happened in coincidence with the emergence of low cost, yet powerful GIS's (e.g. ArcView or Mapinfo), thus, enabling researchers who seek a low cost solution to experiment with VRGIS. According to the survey, many new VRGIS research initiatives use VRML (near to 50% of total application).

Taxonomy of VRGIS application

Though it is possible to classify VRGIS applications and solutions according to their technical aspects (e.g. the level of immersiveness or the computer platform), in this paper the focus will be on the research areas that are currently active in researching the possibilities of VRGIS. This classification will be used to identify the motives that lead to the current practice in this field.
According to the survey, the next research areas are experimenting the possibilities of VRGIS:

Urban planning - those application range from attempts to produce large scale urban models (Liggett *et al.*,1995), to explorations of collaborative environments for design and planning (Dodge et al.,1997). In those applications, The emphasis is on assessing the visual impact of different planning schemes, and on enabling a group of planners to communicate through the planning process.

Environmental planning and impact assessment - Here, the visualization problems that lead to VRGIS range from assessing the visual impact of a planned forest (Buckley & Berry,1997) to visualization of abstract phenomena like land contamination, or air pollution.

Scientific visualization - The goal here is to explore the possibilities of 3 dimensional geographic/cartographic representations for different scientific purposes. The emphasis is on the visualization method as a goal for itself. In this context, the Carto project of the ACM SIGGRAPH is noteworthy.

Archaeological modeling - most of the application in this area deal with the reconstruction of landscape and structures. The applications that rely on GIS usually use its capabilities to handle a digital elevation model (DEM), and then transfer the surface into a VRML model. The emphasis is on visibility analysis and hypothesis validation (Gillings & Goodrick,1996).

Education - in this area, the theme of "virtual field course" seems to gain popularity - at least in the research community. Examples include the VFC initiative developed in Birkbeck College and Leicester University, or the Virtual Canyon by the Monterey Bay Aquarium Research Institute. Here the goal is to enrich the learning process through visualization of distance or "hard to reach" places. Here the multimedia possibilities of VR play an important role. The ability to add information to a VR scene considered to be one of the important aspects of this environment.

Military simulation and intelligence application - Military simulation, and more specifically flight simulation have been a major driving force for many VR implementations. One of the goals in military VRGIS is to enable a "virtual rehearsal" of a future maneuvre. Recently, simulation of this kind was used by the mission force in Bosnia (SGI,1996). A similar system is used by the British forces in Bosnia (Almond,1997).

By inspecting the range of application and fields, it's possible to draw some observations on the incentives for implementing VRGIS.
Some of the motives to VRGIS are explicit. The main one is to (re)construct landscape and urban settings that don't exist - either "no more" or "not yet". The case of "no more" happen when the archeologist wants to explore an ancient landscape in 3D. VR offers the most attractive environment for such an exploration. The case of "not yet", plays an important role in urban and environmental planning - especially for visual impact of planned buildings and other construction projects (e.g. road, dam or a bridge). While many commercial GIS's are able to conduct a visual analysis, the two dimensional result is hard to grasp and perspective views, fly through movies

and animation are too rigid and enforce the user to a specific point of view. VRGIS adds an important freedom for the end user.

In the military field, the concept of simulation is the driving force. Here, the actual mission is dangerous and by familiarizing the trooper/pilot with the mission area, it's possible to reduce the uncertainty of the mission. This is the only major research field which still strives to imitate reality as much as possible.

The third motive, is the visualization of abstract variables, and by that "bringing them to life". This theme is gaining an overall popularity in recent VR applications. However, in VRGIS those applications tend to create a hybrid representation of the "virtual variable" on a background of "real variable". The abstract variable is usually an environmental variable (such as air pollution level) though there are sparse examples for socio-demographic or socio-economic variables.

A fourth motive is to improve communication of ideas and concepts in a collaborative process like architectural planning. In this type of process, the VRGIS acts as a mediator and transmitter of ideas between the participants (Campbell & Davidson,1996). In the GIS realm, the goal is to support users that are "overwhelmingly map illiterate" (Jacobson,1995). This leads to the fifth motive which is the search for an intuitive interface for spatial technology.

Finally, though provocative, one of the identified implicit motives that led to VRGIS is the "Hammer looking for a nail" (A solution looking for a problem). GIS captures and stores spatial data, and since many developers of VR applications are looking for applications that will be used as a case study, it's not surprising that GIS is used as a test case. Examples for this type of application appear in scientific visualization, or the CAVE GIS project (Sullivan *et al.*,1995). Those projects tackle a real problem, but the projects serve as an example of future implementations of a certain technology rather then confronting the problem itself.

Properties of VRGIS

The ideal VRGIS described by Faust (1993) as having the next features:

1. Very realistic representation of real geographic areas.
2. Free movement of the user within and outside the selected geographic terrain.
3. Standard GIS capabilities (query, select, spatial analysis etc.) in a 3D database.
4. The visibility function should be a natural and integral part of the user interface.

In the light of this view it is clear that such systems do not exist yet. Nowadays, the connection between the GIS and VR is in a modular way, in which the GIS is used to create and process the geographical data, and by using a transferable file format (most notably VRML), the information is passed to the VR package for representation (Berger *et al.*,1996). VRGIS solutions are based on coupled systems, with a distinctive GIS module and a distinctive VR module.

Currently, the main properties of VRGIS are:

1. The system database is a traditional GIS.
2. The VR functionality is used to augment the cartographic capabilities of the GIS.
3. More and more solutions use the VRML standard, albeit its limitation. As a result, the VRGIS comes with an Internet functionality "out of the box".
4. There is a trend toward PC based systems, relying on desktop GIS.
   and
5. Loosely coupled VR and GIS software. The graphic data is usually transferred through a common file format, and the synchronization between the systems is based on communication protocol - such as RCP.

Future Directions

VRGIS is only in it's infancy. As the survey shows, even with the basic requirements of VRML and desktop GIS packages, the present desktop system does not have the needed "horse power" to run a full fledged VRGIS. Today, only a CAVE based system (with High Performance Computing such as IBM SP2) can support a real time VRGIS. Based on present practice it is possible to predict when VRGIS will "hit the desktop". The first buds are already appearing in the market - such as the Imagine Virtual GIS (Erdas,1997) or the 3D analyst extension to ArcView (ESRI,1997).

Haklay, M., 1998, *A Survey of Current Trends in Incorporating Virtual Reality and GIS*, in Proceedings of GIS Research UK 1998, Edinburgh, UK, 1-2 April. pp. 10-6 - 10-9

however beyond those implementations there are still open questions on VRGIS. Some of the most interesting are:

- The role of the raster model in VRGIS. Today, the main use of raster layers is to drape them over a polygonal representation of the terrain or the urban setting. What is the role of 3D raster GIS?
- The need to develop proper visualization techniques that can improve communications between the different users of VRGIS. Especially when those systems will be used for policy making and resource management (Gimblett,1993).
- As Liggetti and her associate (1995) demonstrate - there might be an intrinsic difference in the database structure requirements between GIS and VR. There is room for research on the right method and data model that will be the most efficient for VRGIS.
- In accordance to Mennecke (1997), it should be noted that after proving that VRGIS is possible, the human interface part of it should be studied in grate detail, in order to define and develop the proper environment for human interaction with those systems. This problem is enhanced by the growing number of "GIS illiterate" users, who use GIS in their day to day work (sometime without knowing that they use GIS).

Reference

Almond, P., 1997, British Soldiers Plug Into Virtual Reality, *TechWeb News*, Available World Wide Web: URL: http://www.techweb.com/ (Accessed 8 December 1997).

Bell, G., Parisi, A and Pesce, M., 1996, *The Virtual Reality Modeling Language -Version 1.0 Specification*, Available World Wide Web: URL : http://vag.vrml.org/VRML1.0/vrml10c.html. (Accessed 8 December 1997)

Berger, P., Meysembourg, P., Sales, J. and Johnston C., 1996, *Toward a Virtual Reality Interface for Landscape Visualization*, in: Third International Conference/Workshop on Integrating GIS and Environmental Modeling CD-ROM.

Buckley, D.J., and Berry, J.K., 1997, Integrating Advanced Visualization Techniques with Arc/Info for Forest Research and Management, Proceedings: 1997 ESRI User Conference Proceedings, San Diego, CA, July 8-11, 1997

Campbell, D. A., and Davidson J. N., 1996, Community and Environmental Design and Simulation - The CEDeS Lab at the University of Washington in Bartol, D., *Designing Digital Space: An Architect's guide to Virtual Reality,*

Dodge, M., Smith, A., and Doyle, S., 1997, Urban Science, *GIS Europe*, **6**(10)

ERDAS,1997, IMAGINE Virtual GIS white paper, Available World Wide Web: URL: http://www.erdas.com/before/whitepapers/virtualgis_white_paper.html (Accessed 8 December 1997).

ESRI,1997, Announcing ArcView 3D Analyst, ESRI - Press release 3 June, Available World Wide Web: URL : http://www.esri.com/base/news/releases/97_2qtr/3danlyst.html (Accessed 8 December 1997).

Faust, N.L., 1995, The Virtual reality of GIS, *Environment and Planning B: Planning and Design*, 22, pp. 257-268

Gillings, M. and Goodrick, G., 1996, Sensuous and Reflexive GIS Exploring Visualisation and VRML, *Internet Archaeology*, 1, Available World Wide Web: URL: http://intarch.ac.uk/journal/issue1/gillings_toc.html (Accessed 8 December 1997).

Gimblett, H.R.,1993, *Virtual Ecosystems*, Available World Wide Web: URL http://nexus.srnr.arizona.edu/~gimblett/virteco.html (Accessed 8 December 1997).

Hughes, J. R. ,1996, Technology Trends Mark Multimedia Advancements, *GIS World*, **9**(11).

Jacobson, R., 1995, Virtual Worlds: Spatial Interface for Spatial Technology, *electronic Atlas*, **5**(4).

Liggetti, R., Friedman S. and Jepson W., 1995, *interactive design/Decision Making in Virtual Urban World: Visual simulation and GIS*, Proceedings: 1995 ESRI User Conference Proceedings, Palm Springs, CA, May 22-26, 1995.

Mennecke, B. E.,1997, Understanding the Role of Geographic Information technologies in Business: Application and Research Directions, *Journal of Geographic Information and Decision Analysis*, **1**(1).

SGI, 1996, Making A Difference In Bosnia, *IRIS On* Line, **4**(2).

Haklay, M., 1998, *A Survey of Current Trends in Incorporating Virtual Reality and GIS*, in Proceedings of GIS Research UK 1998, Edinburgh, UK, 1-2 April. pp. 10-6 - 10-9