Community Exploration of Changing Landscape Values: the Role of the Virtual Environment

Xiaogang Chen
Department of Geomatics, University of Melbourne, V3010, Australia
xc@unimelb.edu.au

Ian D. Bishop
Centre of GIS and Modelling, University of Melbourne, V3010, Australia
idbishop@unimelb.edu.au

Abdul Rahim Abdul Hamid
Faculty of Architecture, Building & Planning, University of Melbourne, V3010, Australia
a.hamid@pgrad.unimelb.edu.au

Abstract

Virtual reality (VR) technology creates geospatial virtual environments (GeoVEs) and augments the spatio-cognitive aspects of human awareness. GeoVEs offer innovative ways of spatial concept formation and spatial knowledge construction. Many applications suggest its substantial potential for exploration of both natural and built-up environments. To extend this potential the GeoVEs should be linked to the data manipulation and analytical capabilities of geographic information systems (GIS). However, much work in integrating GIS features, system implementation, effectiveness testing and human subject evaluation lies ahead. This paper introduces a preliminary stage of this development: the building of the 3D models from GIS data sets, construction of different simulated environments, and a limited group survey of the acceptability of simulated environments. GIS data includes a digital terrain model (DTM), rivers, streams, boundaries, roads and vegetation classes. Pairs of aerial photographs were also registered and mosaiced as drapes on the DTM. As the project develops, various levels of visual and modeling sophistication for exploration of changing landscape values will be available, with particular focus on detailed and effective visualization to allow local people of any background to be actively involved in reviewing landscape options. Human subject evaluation and effectiveness tests for the new technology are being used to determine the acceptability of different presentation options.

1. Introduction

1.1 Geospatial Virtual Environments

The use of virtual reality (VR) technology in geo-sciences, either immersive or non-immersive, to create geo-spatial virtual environments (GeoVEs) fundamentally changes the traditional way of acquiring spatial knowledge, and extends the spatio-cognitive capabilities of human beings [1,2,3,4]. GeoVEs offer an intuitive way of manipulating data and enhance our interaction with geospatial-data through innovate ways of interactive exploration, spatial concept formation and spatial knowledge construction [5]. Many applications suggest the substantial potential of GeoVEs for exploration of both natural and built-up environment [6,7,8]. Besides, they show greatest benefit for depicting intangible worlds, which cannot be seen in traditional ways. However, much work in integrating GIS features, system implementation, and effectiveness testing through human subject evaluation lies ahead. Recently, research has focused on four factors of "I", i.e. Immersion, Interactivity, information Intensity and Intelligence of objects [3]. In the context of research described here, visual realism is important. However, the complexity of the world is such that abstractions and omissions are necessary to keep the data acquisition task manageable and to keep image generation time acceptable. In the following, we will address issues, arising from our on-going research, on linking GIS and GeoVEs for data manipulation and visual exploration, and acceptability testing under different levels of detail.

1.2 Origin and objectives of the research

The Australian landscape is shaped by the values of the inhabitants. Yet their values may remain inappropriate to the fragility of the environment. For example, Cudgewa Creek catchment, North-eastern Victoria (Fig. 1) is of national significance since the landscapes of the Murray (VIC and NSW), Ovens and Kiewa catchments supply over 50% of the entire fresh water the Murray-Darling Basin. In this, and many areas of the country, livestock production is the dominant enterprise. However, there is a pressure for changes in many areas as tourism and life style development push land prices higher or forestry becomes more economic. Accordingly, both the structure of rural communities and the visual landscape may change markedly in the next 20 years, probably without consideration of either local or wider community values - the visual character and environmental health of the region. Individual and community values are also often poorly communicated and understood.
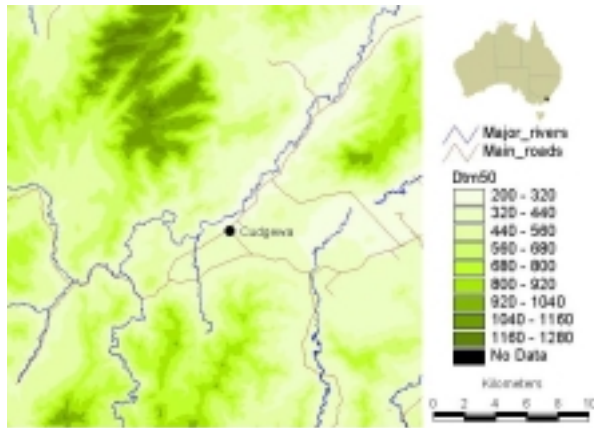

Fig.1　　Location of Cudgewa Creek Catchment.

Recently, there has been a growing recognition that the landscape provides multiple benefits – water, bio-diversity, recreation, aesthetics – and these shape people's landscape values. The project, *Community Exploration of Changing Landscape Values,* intends to create a simulated environment for landscape evaluation, help people learn about their local landscape, and support informed decisions about land use. Particularly, it aims at

- Developing a computer system linking GIS and virtual environment technology for the input of land use change options;
- Integrating environmental, economic and demographic data, existing scientific and local knowledge with the technology to produce a virtual

landscape simulation environment which allow communities to express their values and explore the consequences of land use change, to better understand the dynamic relationship between landscape change and personal values;
- Applying the tools and demonstrating their effectiveness while conducting systems evaluation with the local community in the Cudgewa Creek catchment.

2. System Development

Development of GeoVEs from GIS data is being increasingly automated [9]. Our development is a mix of system-based and manual procedures. It involves following major phases: 1) creation of geospatial database and texture library, 2) data format conversion and processing, 3) feature extraction and visualisation, 4) 3D modelling, simulating and rendering 5) interactive and exploratory analysis and 6) effective testing. In the PC environment, ArcView 3.2 (and more recently ArcGIS 8) with multi-extensions is used for data format conversion, feature generation, two dimensional mapping and visualization, three-dimensional visual analysis. Smart Image and ERDAS Orthobase have been used for aerial photo processing, registration and mosaicing, and Photoshop 6.0 for texture creation and image format conversion. The real-time 3D system has been developed using Performer [10] and OpenGL libraries under IRIX (Silicon Graphics) and Linux (PC) operating systems. The Linux option allows for low cost portable installation suitable for use in public forums.

Immersion is provided by the use of three-screens and three projectors to give a 135 degree field of view. Real-time computer performance in such an environment is commonly based on a single very high performance computer (e.g. SGI Infinite Reality). Because of budget restrictions and the need for easy portability, three low cost computers will be used – one for each projector. This however has required some special software development. We have used both Poetic Dimension (PD from Immersion Studios, Toronto) and our own development (PA – object Animation with Performer) to link the 3 rendering computers [8]. A fourth 'master' computer can be used to control operations and this is network linked with computers supplying the base information. A change in the modeled virtual environment will, for example, be triggerable from ArcGIS on a workstation or purpose-developed decision support software on multiple pocket-PCs used by the stakeholders.

3. Geo-data source and 3D Modelling

3.1 GIS data manipulation

The original GIS data cover topographic, thematic and image data, which provide information on location, features, types and distribution of geographic objects. The following steps were taken in development of these into a 3D landscape modelling and visual geo-analysis for the study area.

- Topographic data were provided by Land Victoria. These included contours for generating DTM, rivers, streams, boundaries and roads. These linear features were provided in Intergraph .dgn format and processed as follows:

  i. Extract topographic data using layer query from 10 sub-areas covering an area of approximately 40 km by 40 km;

  ii. Merge 10 sub-area data into an entire data set, separated in layers of major stream, minor stream, dams, major roads, roads and boundaries (i.e. fence lines);

  iii. Convert data set from CAD format into Arc View shape files, organized by theme. Examples of major road and boundaries are shown in Fig.3a.

- Thematic data include the existence, class and density of vegetation, provided in vector format by Victoria's Department of Natural Resources and Environment (NRE). Vegetation data are geo-processed using Arc View to generate new codes as vegetation type-density classes. All grid-based data manipulation was based on a 10 m cell size.

- Aerial photos, originally from Qasco-VicImage, are rectified based on topographic data, such as roads, rivers and then mosaiced into the entire aerial photo for the first focus area.

- All topographic data, thematic data and aerial photos are then clipped into a test area of 8 x 9 sq. km and a sub area of 1 x 1 sq. km, under unified geo-reference.

3.2 Generation of 3D data and simulation of environments

Terrain

ArcView 3D Analyst extension built the DTM (at 10m, 50m and 500m grid sizes) from the original 10 m contours. The different DTMs were exported as ASCII

raster files (.asc). A program was especially written to convert these to Alias-Wavefront (.obj) format files.
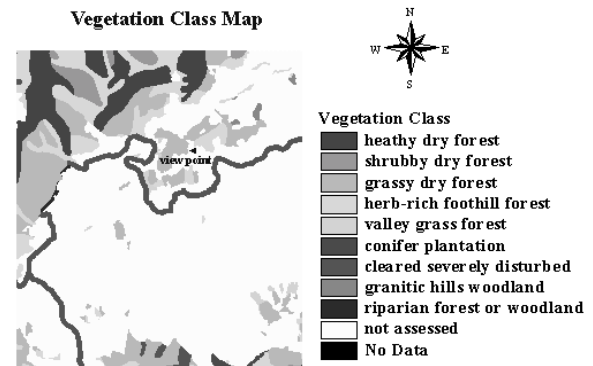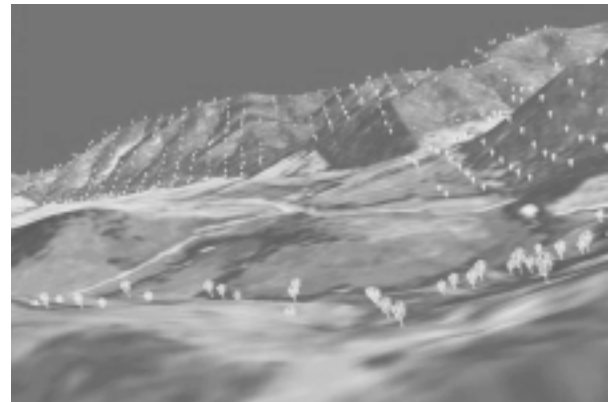

Figure 2a Vegetation class map

Figure 2b Treed areas in the simulated environment

Vegetation

Treed areas: The vegetation type-density classes were also exported from ArcView as .asc files. When processed in conjunction with a DTM, different DTM cells were allocated to different groups on the basic of their type-density class. Another user-written program generated .obj files with trees covering the corresponding portion of the DTM. The vegetation mapping and corresponding low density (and excessively regular) version of this tree-covered simulated environment are displayed in Figure 2a and 2b. Different tree models/textures can be applied for each defined group.

Individual trees: individual trees (coordinates) were identified and positioned from the rectified and mosaiced aerial photos in ArcView. In ArcView 3.2, development of a file with the x,y and z positions of each tree involved a series of step including gridding the location file,

multiplying by the DTM and merging of attribute tables. This process is much simplified in ArcGIS 8 with x,y and z values for the point exported as a text file.

Buildings

This were positioned and modeled in much the same way as the individual trees but with a somewhat more complex structure applied to each building. Houses were distinguished from farm sheds and a variety of simple generic structures defined (Figure 3b).
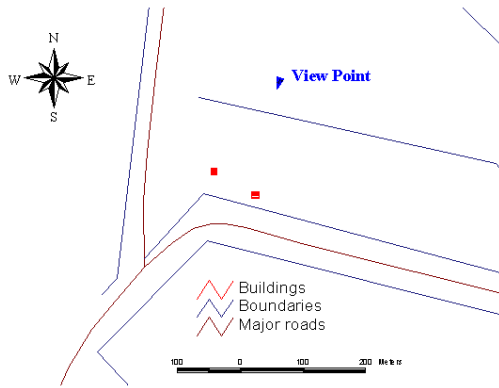

Figure 3a   Local view of buildings and farm shed

Fences

The option of assigning z values (from the DTM) to a line and exporting as .dxf was used here. Vertices are assigned at each DTM grid cell (i.e 10 m spaces in this case). The dxf file was processed by another in-house program to extrude the boundary lines by 1 m in Z. This created a series of panels 10m long and 1 m high. A fence texture was created using Photoshop, converted to .rgba format (for transparency) and applied to these panels (Figure 4b).

Roads

Road center lines were exported as a .dxf in the same manner as the fence lines. These were converted to .obj files and then processed again to produce a corridor of specified width. Photoshop was used to create a texture for the road surface (Figure 4b).

Figure 3b Buildings in simulated environment: house on the right, farm shed on the left

4. Interactive presentation, analysis and exploration

Interactive visualization shows the distribution and pattern of environmental elements and their interrelation. It links maps and database as well as providing access to the tools for describing, measuring and manipulating relevant data. A good visualization also allows for retrieval of information and analytical outcomes, and for exploration of hidden regularity with spatial and temporal references [11]. While these attributes are more commonly applied to more abstract scientific visualization they ideally also apply when a component of the system is a virtual environment. Such is the objective of interactively linking the GIS with the GeoVEs and with simple devices for individual or group input.

Consider the following scenario. Tree decline is an increasing problem throughout the Cudgewa catchment on farmland, roadside reserves and public land. Lands without vegetation or with scattered vegetation cover 71 % of the study area. However, many people believe that the large areas of existing native forest in the area reduces the need to protect remnants and prevents tree decline, which may cause even more serious tree decline, especially on the lower slopes and creek flats. Red gums, as an example, have been over-cleared and the remnants are at serious risk of dying out in some areas [12]. This issue raises great concern throughout the area. GIS analysis and virtual environment exploration will help the community to understand the current situations.
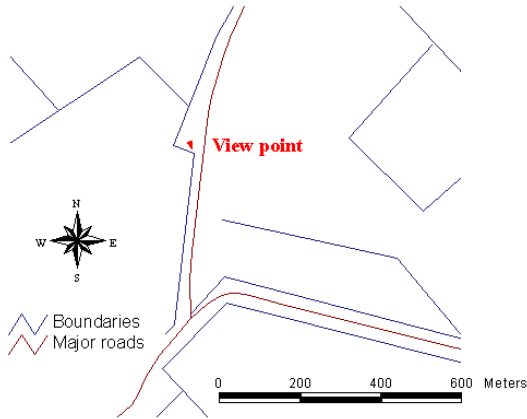
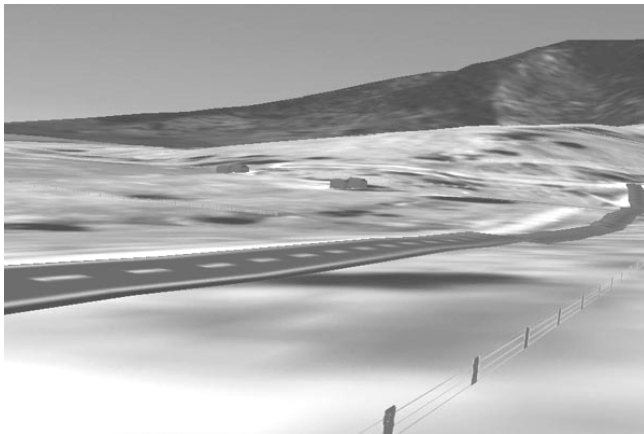Figure 4a   Local view of boundary and major road map

Figure 4b Major road and fence-simulated environment

Using existing GIS based maps of ecological condition of the vegetation (density, diversity of vegetation species and their distribution over space) and stochastic models of decline it is possible to reveal in mapped form the human impact on the remnants over time. What if..? games can be played to change patterns of pasture or weed management which may affect the native trees. At the same time, weed spread can be modelled under different control scenarios.

But, we assume, this becomes much more effective for local residents when the interaction and immersion provide a level of presence in the VE. GeoVEs offer an intuitive way of manipulating data and enhances the interaction with the geospatial data to create new ways of interactive exploration, spatial concept formation and spatial knowledge construction. Real-time tracking with six degrees of freedom is available for interactively manipulating triggered features, such as trees, water bodies, roads, buildings and fences. The availability of vivid and detailed visualization provides realistic views of the study area from any ground or aerial viewpoint, allowing walk or drive through and fly over the modelled environment, thus creating a platform for local people to be directly and personally involved in changing landscape values.

5. Accepability

Clearly a trade-off still exists between level-of-detail in computer graphics and refresh rate. In order to provide real-time performance and autonomous exploration of the GeoVEs, some simplification is necessary in the 3D model in order to keep polygon numbers manageable. Figure 5a and 5b show a pair of real and computer generated views from the same location within the data set. It is easy to see which is the VE view and it is also apparent that the VE view is inadequate in terms of foreground detail. There are roles for which the simulation is not appropriate – but is it acceptable for the role anticipated in this project?

To address the issue, we have undertaken an "acceptability of landscape simulation" survey. At current stage, 63 undergraduate and graduate students majoring in Landscape Architecture and Geomatic Engineering have responded. They were exposed to pairs of static computer-simulated images and real digital photographs. These showed different combinations of fore, middle and background vegetation, buildings and fences. A series of questions about the identification of features and cognitive understanding and level of ease of interpretation of images were asked. Later on, local people in the Cudgewa area will be asked further questions about recognition of the location, recollection of features and interpretation of changes to examine the suitability of GeoVEs used in this project. Then, static views and 3D, dynamic, interactive, semi-immersive simulated environment in fly or drive mode will be provided with different settings of parameters to test the effectiveness and acceptability of construction of virtual landscapes. This aspect of the research should answer the questions
- What number and growth of different tree types are required to be represented
- Whether all trees need to be present or only a sub-set
- The role of vertical exaggeration
- How is foreground and erosion best portrayed
- How is time best represented dynamically

The quality of representation will also improve as more objects and additional vegetation types are added to the library.

Figure 5a Real view

Figure 5b Simulated view

6. Conclusion

We have just begun to explore the potential of coupling GIS and VR technology for applications. It is apparent that GIS provides precise positioning for VR modelling and exploration, which in turn provides visually interactive spatial and 3D analysis for environmental knowledge construction. The availability of vivid and detailed visualization provides semi-realistic views of the study area from any ground or aerial viewpoint. Preliminary environmental modelling and visual exploration through realism and abstraction, and effectiveness testing from students with design and IT backgrounds have been conducted. If these views are of acceptable detail and quality to local people, they allow community members from any background to participate in a discourse on landscape values and consequent decision-making.

7. References

[1] MacEachren, A.M., Edsall, R., Haug, D., Baxter, R., Otto, g., Masters, R., Fuhrmann, S. and L. Qian. 1999. Exploring the potential of immersive virtual environments for geographic visualization
http://www.geovista.psu.edu/publications/aag99vr/fullpaper.htm

[2] Neves, J.N. and Camara, A. 1999, Virtual environment and GIS, *Geographic information systems*, Vol.1, Edited by Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., John Wiley & Sons, Inc.

[3] Slocum, T.A., Blok, C., Jiang, B., Koussoulakou, A., Montello, D.R., Fuhrmann, S. and Hedley N.R. 2000, Cognitive and usability issues in geovisualisation, *Cartography and Geographic Information Science*, Vol.28, No.1, 2000 – 1.

[4] Hedley, N.R. 2001, Virtual and augmented reality interfaces: Empirical findings and implications for spatial visualization, *Proceedings of 20th International Cartographic Conference*, Beijing, China, 2001 (CD-ROM)

[5] Buziek, G. and J. Dollner. 1999, Concept and implementation of an interactive, cartographic virtual reality system, *Proceedings of 19th International Cartographic Conference*, Ottawa, Canada, 1999 (CD-ROM)

[6] Bishop, I.D. and Karadaglis, C. 1997 Linking modelling and visualization for natural resources management. *Environment and Planning B: Planning and Design 24*: 345-358

[7] Verbree, E., Van Maren, G., Germs, R., Jansen, F. and Kraak, M.-J. 1999, Interaction in virtual world views – Linking 3 D GIS with VR. *International Journal of Geographical Information Science*, 13 (4), 385-396.

[8] Bishop, I.D. and Dave, B. 2001, Beyond the moving camera: system development for interactive immersive exploration of urban environments, *Proceedings for Computer in Urban Planning and Urban management*, Honolulu, July, 2001.

[9] Perrin, L., Beauvais, N. and Puppo, M. 2001, Procedural landscape modeling with geographic information: the IMAGIS approach, *Landscape and Urban Planning 54* 33-47.

[10] Rolf, J., and Helman, J. 1994, IRIS Performer: a high performance multiprocessing toolkit for real-time 3D graphics. *Proceedings of SIGGRAPH 94*, , Orlando, FL, ACM SIGGRAPH 381-394.

[11] Kraak, M.-J. 1999, Visualising spatial distribution, in *Geographic Information Systems*, Vol.1, Edited by Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., John Wiley & Sons, Inc.

[12] *Cudgewa Landcare report*, edited by Tom Croft, 1998. North-East Catchment Management Authority, Victoria