Exploring Virtual Geographic Environments

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Abstract

Virtual geographic environments (VGE) are environments pertaining to the relationship between post-humans and 3-D virtual worlds. Post-humans are defined as a combination of humans in the real world with 3-D avatars in 3-D virtual worlds. Five types of space, namely Internet space, data space, 3-D graphical space, personal perceptual and cognitive space, and social space are used to explore the characteristics of VGE. The evolution of VGE is illuminated via three stages: virtual crowds, virtual villages, and virtual cities. Taking VGE as study object, virtual geography can be defined as a discipline to study the characteristics and laws involving VGE as well as the relationship and interaction between VGE and real geographic environments. Different from VGE, georeferenced virtual environment systems allow distributed users to congregate virtually on the Web and interact with 3-D graphical worlds to explore the Earth's geographic phenomena and processes in an immersive or semi-immersive way. They can be divisions or whole virtual laboratories embedded in VGE. In this paper, a georeferenced virtual environment system prototype, called VirtualPark, is developed for managing and disseminating information regarding the Shing Mun Country Park in Hong Kong, and for facilitating public participation in policy-making, protection of ecological systems, and the development of the tourism industry.

I. INTRODUCTION

The Internet, the World Wide Web (the Web) and virtual reality generate both new opportunities and new challenges. On the one hand, the Internet and the Web provide open and distributed environments for implementing geo-referenced data dissemination, visualization, analysis and interpretation. Virtual reality technology can be used as an immersive human-computer (human/geo-referenced data) interface for 3-D exploratory visualization, collaborative work, and group decision-making through integration with traditional GIS and 3D GIS (Doyle and Dodge, 1998; Dykes *et al.*, 1999; Green, 1997; Plewe, 1997; Verbree *et al.*, 1999). On the other hand, in this information society, the importance of geographic distance and place has gradually decreased. Online communities and virtual company exist in cyberspace (a very complicated, hyper information space), with their locations at "elsewhere" (i.e. at nowhere). This means that such a reality is made up solely of space with no places. Geography, however, is the science of place and space (AAG, 2001). As a result, researchers address the annihilation of places, shrinking distance and time to zero, and even the death of geography in virtual worlds that leads to a deep thinking and wide discussion for geographers in the context of future geography (Cairncross, 1997; Couclelis, 1996; Crang et al.,1999; Dodge, 2001; Kitchin, 1998; NCGIA, 1998).

Virtual geography, cyber geography, imagined geography, and geography in the information society are all the similar terms found in the present literatures that show the impact of modern information technology on geography (Batty, 1997; NCGIA, 1998). Batty (1997) examines virtual geography in terms of geographic space-place, cspace, cyberspace, and cyberplace, and his ideas of virtual geography focus on space-place and the relationship and interaction between cyberspace (the Internet and the Web) and the physical (material) world. But he argues the boundary between space and place in cyberspace turns blurred, therefore gives no further discussion on the issue concerning the dead of place in cyberspace. Highlighting virtual technologies and social relationship embedded in virtual technologies, Crang *et al.*'s (1999) examination of virtual geography is mainly from the relationship between real worlds and virtual worlds in terms of complicated social context. They address that focus on what sort of virtual technosocialities one chooses decides the character of virtual geographies, thus the research objects and contents of virtual geography are not evidently presented.

This paper aims to explore the geographic characteristics of cyberspace from the perspective of 3-D virtual space and 3-D virtual place. The structure of the paper is organized as follows. The second section addresses the concept of virtual geographic environments (VGE). Then we describe the different spaces within VGE. In the fourth section, the evolutionary process of VGE is explored. In the followed section, we present the concept and research contents of virtual geography. Using the Shing Mun Country Park in Hong Kong as a case, the sixth section addresses a georeferenced virtual environment prototype for implementing data visualization and analysis, collaborative work and virtual trip. The last section concludes the paper.

II. DEFINITION OF VIRTUAL GEOGRAPHIC ENVIRONMENTS

To date, everything in this material world is being virtualized. Space-place becomes virtual space-flow, thus events occur-

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ring in cyberspace cannot be accurately located. But the continuous development of technologies such as 3-D graphics, visualization, virtual reality, and web-based VRML (the Virtual Reality Modeling Language) leads to the emergence of 3-D virtual worlds in cyberspace (Carey and Bell, 1997). With virtual space and virtual place, 3-D virtual worlds provide places where post-humans can work and live. In this environment, post-humans are the combination of humans in the real world with 3-D avatars that are 3-D graphical representations of participants in 3-D virtual worlds. In comparison with the concept of real geographic environments in the physical world, VGE can be defined as environments pertaining to the relationship between post-humans and 3-D virtual worlds (Gong and Lin,2001). But the term *geographic* in relation to real geographic environments and VGE needs further explanation. *Geographic* in terms of real geographic environments mainly involves space and place on the Earth, while *geographic* in terms of VGE involves space and place, not only on virtual Earth but also in other 3-D virtual worlds such as virtual Mars, virtual Moon, and imagined 3-D worlds.

VGE may have something to do with current georeferenced virtual environment systems, but they are different. In order to examine their relationship, we first discuss the concepts of virtual environments and georeferenced virtual environment systems.

At the present, immersive virtual reality (VR) and online VR are the two main aspects of virtual environments (Batty et al., 1998; MacEachren et al., 1999). Traditional virtual reality technology makes participants interact and communicate with realistic 3-D objects in an immersive or semi-immersive way. Projected VR systems allow many users to participate in the same virtual world in a semi-immersive way. VR systems with headsets, data-glove, data suit and accessories provide the capability of "implanting" users into 3-D worlds that engender similar feelings of realism to those of the material world. Based on the Internet and the World Wide Web, online VR, however, enables distributed users to congregate virtually, and to interact with each other, and with shared virtual 2-D or 3-D worlds. Furthermore, we argue immersive VR focuses on the relationship between users (in the same place) and virtual 3-D worlds, while online VR focuses on the interaction among users located in different places in a virtual society. Virtual environments thus can be defined as the integration of major elements of immersive VR and online VR that allow distributed users to get together virtually and interact with a 3-D graphical world in an immersive or semi-immersive way on the Web..

On the one hand, if environments simulate or represent geographic environments, either in reality or in possibility (i.e., if environments describe geographic phenomena and processes), the virtual environments will specifically be the georeferenced virtual environment systems. On the other hand, if virtual environments evolve into complicated systems with many immigrants and specific social, political, and economic structures, then the virtual environments will be VGE. Although VGE may be related to georeferenced geographic environment systems, there are differences. VGE are complex, nonlinear, self-organized, evolving systems in which there are many 3-D virtual objects and virtual people who lead virtual social, political, and economic lives. Georeferenced geographic environment systems, on the other hand, are regarded as application tools that enable us to implement georeferenced data handling and analysis for knowledge seeking, urban planning, or decision-making support. So georeferenced virtual environment systems can be seen as divisions, or as whole virtual laboratories embedded in VGE for handling geographic phenomena and processes on the Earth.

As an example, Alphaworld, a famous Internet based online community, now has over 800,000 unique users and over

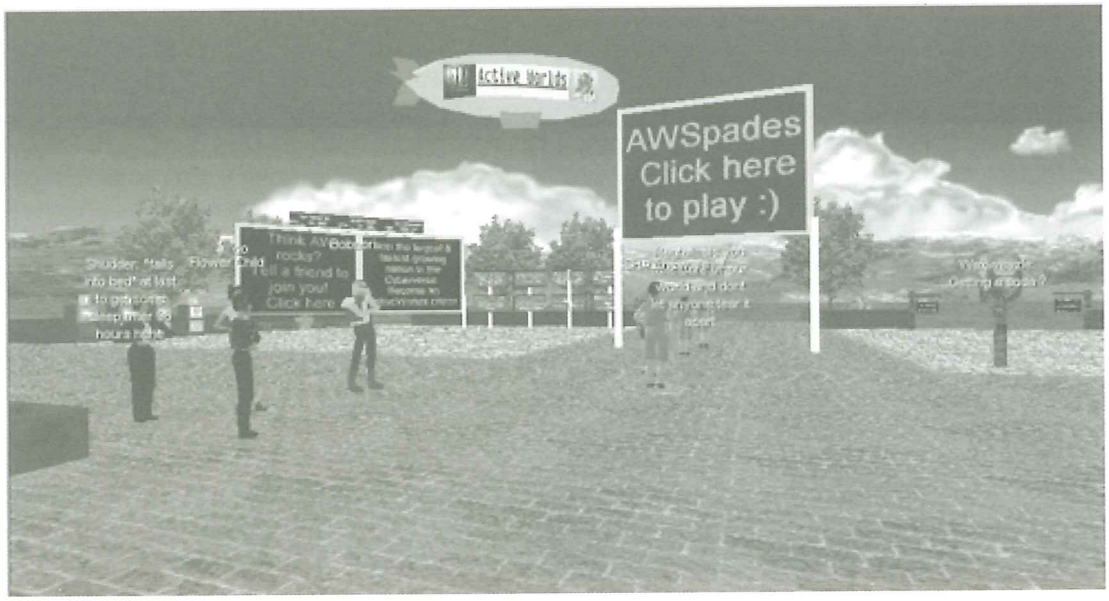

Figure 1. A 3-D virtual place of alphaworld, image courtesy by Activeworlds.com

20,000 unique paid members (Active Worlds, 2000). Each member can build his house in Alphaworld. Figure 1 shows a 3-D Alphaworld site where many online users employ 3-D avatars to navigate the world and talk with each other. Figure 2 describes a 'satellite' map of Alphaworld landscapes in August 1999. Alphaworld can be considered as a newborn, simple but evolving virtual geographic environment.

III. CHARACTERISTICS OF VGE

VGE are mad up of various components, involving information infrastructure, data, 3-D graphics, personal perception and cognition, and social behavior. To explore the characteristics of VGE, we design five types of space, namely Internet space, data space, 3-D graphical space, personal perceptual and cognitive space, and social space.

Internet space

To date, numerous computers assigned with IP addresses (short for Internet Protocol addresses) are connected into an Internet space. Internet space is a physical foundation of cyberspace and is the connection of virtual world and real world. By mapping Internet space onto real geographic space, spatial patterns of Internet space in some regions can be obtained and used for analyzing the impact of the Internet on regional social and economic development (Dodge, 1999).

Data space

VGE are constructed on a base of ordered, structured, 3-D data space. Most objects existing in virtual worlds are in 3-D forms. Vast amounts of data, multi-resolution representation, distributed spatial data models, shared objects and data interoperability should be taken into consideration. The National Information Infrastructure and the National Spatial Data Infrastructure in USA, China and so on work towards building data space for VGE (Cheng *et al.*, 1999).

3-D Graphical space

3-D graphical space is the external representation of data space, that provides users with 3-D locations, enables users to carry out immersive navigation and interaction using direct senses, and helps people easily memorize 3-D scenes and events happening in 3-D virtual worlds.

Personal perceptual and cognitive space

In VGE, users may obtain perceptual space via interaction of visual, auditory, tactile, thermal, kinesthetic and even olfactory senses with virtual objects, and feel immersive and present as they do in the real world.

Moreover, 3-D avatars are often used to represent users in online virtual environments. Figure 3 shows some 3-D avatars representing Asian and African people. A varied selection of avatars of different sex, body size, age, motion speed, or object types such as butterflies, deer or airplanes may lead to varied cognitive space within the virtual environments.

Social space

People in VGE may choose avatars to form their identities, and play different roles in various social activities. There are also many communities divided by space, interests and other factors. In particular, some current VGE such as Cybertown have their own constitution, social, political and economic structures (Cybertown, 2000).

IV. EVOLUTION OF VGE

Evolution of VGE is a process from void to being, small to big, and simple to complex. There are three stages in the evolutionary process, from a website to a 3-D virtual world: virtual crowds, virtual villages, and virtual cities (Cybertown,

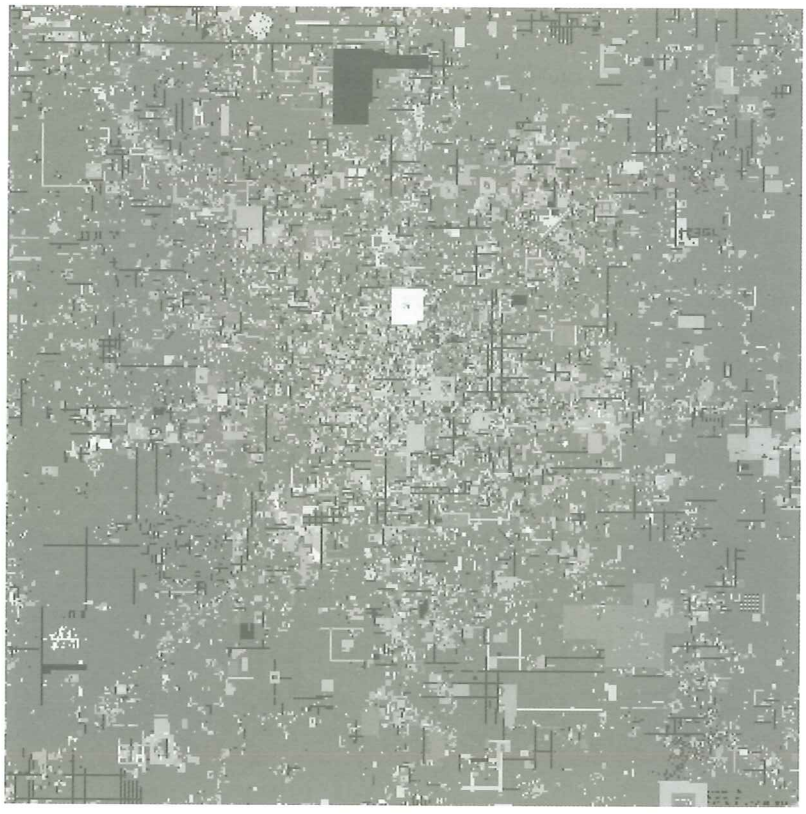

Figure 2. 'Satellite' map of alphaworld landscapes in August 1999, image courtesy by Activeworlds.com

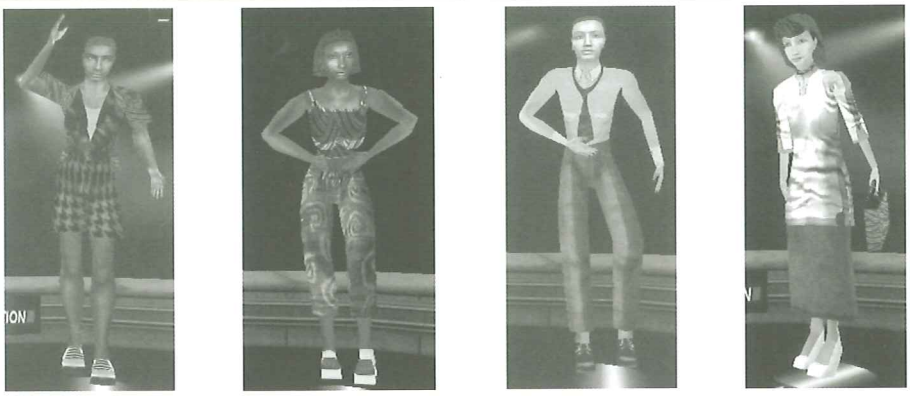

Figure 3. 3-D avatars representing Asian and African people

2000; Rockwell, 1999).

At the stage of virtual crowds, a website can be a place where people can get together and talk with each other. For instance, many current online talk communities like Microsoft Chat rooms on the Internet are virtual crowds. The major characteristics of virtual crowds are as follows. 1) People meet each other by chance; 2) Chat is implemented by text or voice; and 3) Participants can change their identities by changing their names, thus making communication open and free. With the development of virtual crowds, however, some problems occur, e.g., no useful entities other than chat can be found in these virtual crowds, beliefs cannot be established among people with changing identities, and so on. In order to solve these problems, virtual crowds have to develop into virtual villages.

At the stage of virtual villages, shared 3-D graphical spaces with small areas are created in which people can build their own houses. Members of virtual villages all have definitive identities using permanent names and 3-D avatars. Therefore, long term relationships and beliefs may be established. In virtual villages, more events such as meetings, workshops, games, and parties are arranged by the village leaders to enrich the social life of the village. Simple rules and laws are designed and executed in virtual villages to protect private properties or enable members to have the right to allow defined users to enter their houses. However, as more people visit and transmigrate into virtual villages, more space is explored and inhabited, and there is more interconnection of various independent villages, these virtual villages will gradually evolve into virtual cites.

At the stage of virtual cities, 3-D space is very large. For instance, the total area of Alphaworld is 429,038 square kilometers, 4.4% larger than California (Activeworlds, 2000). Therefore, 'satellite' landscape maps are required for spatial navigation, and transportation tools such as buses, trains and airplanes should be provided for rapid transit. In addition, the social, political, and economic structures of virtual cities become more complex. As an example, Cybertown, a well known online community, demonstrates some characteristics of virtual cities (Cybertown, 2000).

At present, Cybertown has 409,000 citizens and four Colonies, namely Entertainment, Games, Sci-fi, and Virtual Worlds. In these Colonies, members can build and own their own houses, and collaborate and socialize with others. Figure 4 shows the Cybertown map; Figure 5 shows the landscape of some of the regions in Cybertown; Figure 6 demonstrates the 3-D Cybertown Plaza where online people communicate with each other. Cybertown has its own 12-point constitution. For example, the first item is "In communication to others in Cybertown follow customary manners as they are (or at least as they should be) followed in real life". Also, Cybertown has its own social, political, and economic structures. In the social strata, there are visitors, members, citizens, and elders; In the political strata, there are the mayor and the city council; In the economic strata, there is CityCash$ (virtual money). Members can earn money by just visiting the community, or by taking jobs such as the mayor, city council members, city guides, world builders, magazine staff, security officers, employment chief, club owners, and so on.

As an ideal model, Cybertown shows us a new life and a new

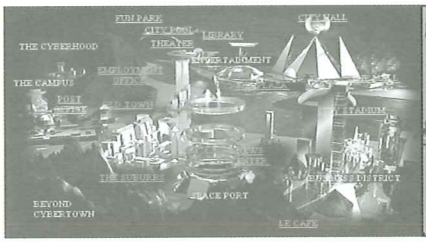

Figure 4. Cybertown map

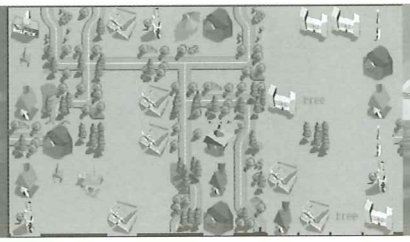

Figure 5. Landscape of some area

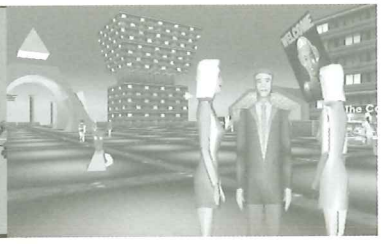

Figure 6. Cybertown plaza

world of different relationships between post-humans and their virtual environments in comparison with the real world. Cybertown, we argue, is nascent VGE.

V. DEFINITION AND RESEARCH CONTENTS OF VIRTUAL GEOGRAPHY

Like traditional geography taking real geographic environments as its study object, we argue, virtual geography is a new dimension of geography studying the characteristics and laws involving VGE as well as the relationship and interaction between VGE and real geographic environments.

Focusing on aspect of VGE, the major research contents of virtual geography include:

- Cybercartography. Cybermaps of Internet space, 3-D virtual landscapes, 3-D virtual worlds and the like enable us to well understand spatial structure and phenomena in VGE. Cybercartography is to study the principles and methodology of cybermapping (Jiang and Ormeling, 1999).
- Development, planning and building of 3-D virtual worlds further including theme selection and development of 3-D virtual worlds, expansion and update planning of 3-D virtual worlds, design and planning of virtual communities, planning of 3-D virtual ecological landscapes, building of virtual landscape database and so on.
- Spatial perception, cognition and behavior of post-humans in 3-D virtual environments. Behavior geography and cognitive psychology are useful for this research concerning multi-sensory interaction and choices of 3-D avatars with different body size, sex, motion speed, and so on.
- Issues in the evolutionary process of VGE including establishment of unified coordinate reference systems of virtual space and time in VGE, boundary and relationship among various 3-D virtual worlds, pattern and spatial distribution of social, political, and economic structures in different 3-D virtual worlds, spatial zoning of a 3-D virtual world, and mechanism of driving forces of evolution of VGE.

Focusing on aspect of the relationship between VGE and real geographic environments, the major research contents of virtual geography include:

- The Digital Earth. The Digital Earth will be a virtual, three-dimensional, and multi-resolution representation of our planet that enables a person to explore and interact with the vast amounts of natural and cultural information gathered about the Earth (Digital Earth, 1999; Gore, 1998). With close relationship of the real Earth in material, energy and information, Digital Earth is very important for human sustainable development on the real Earth, and plays a great role in the evolution of VGE containing many cyber planets such as cyber Moon, cyber Mars, and the other imagined 3-D virtual worlds.
- VGE and regional sustainable development including the relationship of virtual communities and real communities, design and building of virtual laboratories for implementing georeferenced data processing and interpretation, model simulation and scenario forecasting, decision support, and so on.
- Relationship and interaction between VGE and real geographic environments in population, 3-D landscapes, as well as social, political, and economic structures.

VI. GEOREFERENCED VIRTUAL ENVIRONMENT SYSTEMS–A PROTOTYPE

Establishing a website that will evolve into a virtual city with a large population, extensive housing and other 3-D landscapes, and complicated social relationships is a difficult task. To date, there exist a few rudiments of VGE such as Activeworlds and Cybertown (Active Worlds, 2000; Cybertown, 2000). As mentioned above, georeferenced virtual environment systems would have the potentiality to evolve into VGE, or can be divisions or be whole virtual laboratories embedded in VGE for handling geographic phenomena and processes on the Earth. In this paper, using the Shing Mun Country Park in Hong Kong as a case study, we design and develop a georeferenced virtual environment system prototype, called VirtualPark, for managing and disseminating information about the Shing Mun Country Park, and facilitating public participation in policy-making, protection of ecological systems, and the development of the tourism industry. The Shing Mun Country Park is located in Hong Kong's New Territories Region, and covers a total of 1400 hectares (Wang,1998; Country Parks, 2001).

There are a variety of ways to develop 3-D graphics based applications on the Web (Coors and Jung, 1997). The main factors to construct a web-based application involve the choice and combination of traditional programming languages such as C and C++, web-based programming tools such as Java, Java3D, and ActiveX, 3-D scene modeling languages like VRML97, as well as different schemes of thick/thin client and heavy/light server (Lin *et al*, 1999; Rohrer and Swing, 1997; Strand, 1997). This paper employs a balanced client/server structure, Java, VRML EAI and VRML97 to design the VirtualPark architecture (Marrin, 1997; Rhyne, 1999; White and Sonstein, 1999).

In view of the ShingMun Country Park, there are various of 2-D maps and data documents such as topographical contour map, water net, roads, footpaths, public facilities, vegetable types, plant conservation areas, and entertainment planning. They are digitized and edited by using Arc/Info (Version 7.0.3). Arc/View (Version 3.0) is then used to manage and visualize the 2-D maps and connected database. A 3-D georeferenced visualization, Geo3DVision, developed by the

authors , is employed to carry out 3-D display and analysis.

Using Arc/Info and Arc/View, we can get vector data in Shapefile format and raster data in grid. They are then converted into different 3-D objects in VRML through the data model mapping programs, named ModelInterface, developed by our research group with C/C++. In the above conversion process, multi-level models are applied.

In terms of spatial aspect of topographical landscape object, three levels with different triangular irregular networks are adopted to represent geometric distribution. Also, three levels with different resolutions of texture images are applied to describing thematic attribute (Li and Wen, 2001). In view of 3-D individual entities such as kiosks, toilets, and swings, AutoCAD is firstly utilized to create them. Then, they are handled by the data model mapping programs ModelInterface to form 3-D objects in VRML. All the 3D objects are stored and managed by an Oracle database server. In the database, exempt from the essential spatial and thematic attributes, every entity-based 3D object has more attributes (fields) such as ID number, object name, metadata, center coordinate, 3-D boundary box, and general description.

Figure 7 is the interface of VirtualPark. The free browser Cosmo Player (Version 2.1) is adopted to view the VRML world. When VirtualPark is started, every user needs to choose her/is name and avatar. Distributed users interact and communicate through avatars and text-based dialogue. In Figure 7, the upper left hand window is a 3-D world viewing window displaying 3-D mountains, lakes, trees, playgrounds, and two avatars; the upper right hand window for choosing parameters of spatial and thematic levels and thematic type, for implementing data query and object addition/removal, and for outputting information of data query and coordinates; the bottom-left window for text-based talking among online users; and the bottom-right window for displaying a 2-D map of the virtual country park, which closely connects with the 3-D world viewing window.

VII. CONCLUSION

The essence of metaphysics of 3-D computer graphics, 3-D visualization and virtual reality is to allow us to have virtual living places and homes in cyberspace. It is the process from virtual space-flow to virtual space-place that makes VGE and virtual geography appear and develop. Focusing on the research in the context of virtual space and virtual place, virtual geography differs from the other cyberspace-studying disciplines such as communication, sociology, and so on.

VGE refer to environments concerning the relationship between post-humans and 3-D virtual worlds. Post-humans are the combination of humans in the real world with 3-D avatars that are 3-D graphical representation of participants in 3-D virtual worlds. Five types of space, namely Internet space, data space, 3-D graphical space, personal perceptual and cognitive space, and social space are used to demonstrate the characteristics of VGE. The evolution of VGE is illustrated in the three stages of virtual crowds, virtual villages, and virtual cities.

Taking VGE as study object, virtual geography can be defined as a discipline to study the characteristics and laws involving VGE as well as the relationship and interaction be-

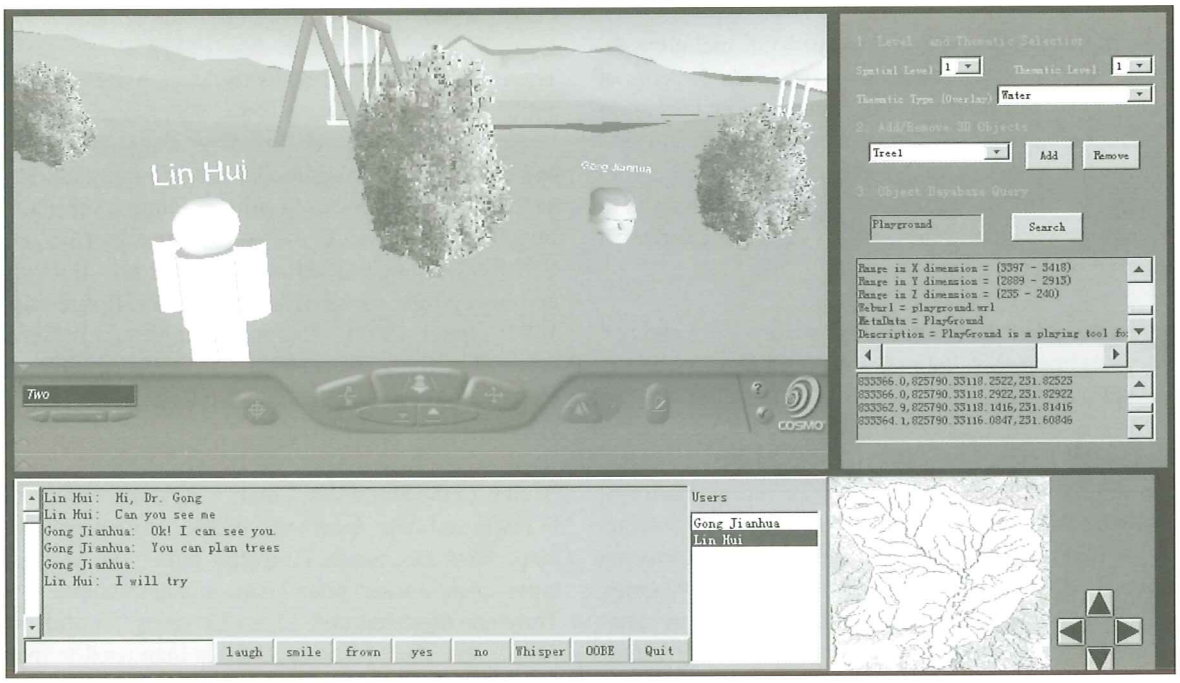

Figure 7. Interface of a georeferenced virtual environment system prototype, VirtualPark

tween VGE and real geographic environments.

In comparison to VGE, georeferenced virtual environment systems allow distributed users to virtually congregate on the Web and interact with a 3-D graphical world to explore geographic phenomena and processes on the Earth in an immersive or semi-immersive way. They can be divisions or whole virtual laboratories embedded in VGE. In this paper, a georeferenced virtual environment system prototype, called VirtualPark, is developed for implementing the management of the Shing Mun Country Park in Hong Kong.

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