Reality-Virtuality Fusional Campus Environment: An Online 3D Platform Based on OpenSimulator

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Abstract This paper presents a reality-virtual fusional campus environment. It is an online 3D platform with some aspects of real information merged together. The whole platform is based on OpenSimulator with detailed geo-models to represent the university campus. Some preliminary experiments were done to integrate the realistic information with the virtual campus for making the geo-environment not only with detailed indoor and outdoor models, but also with the real representations of the physical world. The overall motivation is to provide a framework with strong support for reality-virtuality fusional modeling in a collaborative 3D online platform for research purposes.

Keywords collaborative 3D modeling; OpenSimulator; virtual geographic environment; fusion of reality and virtuality

Introduction

As three-dimensional (3D) virtual worlds like SecondLife (SL) and OpenSimulator (OpenSim) become more mature and technically advanced, they can be used for serious applications driven by research.[1,2] OpenSim is an open source multi-platform, multi-user 3D application server. It can be used to create a virtual environment (or world) which can be accessed through a variety of clients, on multiple protocols.[3] Both SecondLife and OpenSim depend on user created content. They both include programming interfaces to create new functionality. The networked virtual environment allows for intuitive interaction. Our contribution is a new environment (VGE)[4] so the virtual world can support research, simulation, learning, testing, and other work.[5]

Online 3D is becoming more and more popular. The 3D Internet can be defined as one that is navigable in 3D rather than two. Instead of websites, you have explorable regions. Instead of 2D text chatting, you have 3D avatar chats.[6] There are also mirror world and Metaverse, two similar things both based on the Internet. A Mirror World is a representation of the real world in digital form. It attempts to map real-world structures in a geographically accurate way. Mirror worlds offer a utilitarian software model of real human environments and their workings.[7] The Metaverse is the convergence of (1) virtually enhanced physical reality and (2) physically persistent virtual space. It is a fusion of both, while allowing users to experience it as either.[8]

Taking account of the popular virtual reality environments mentioned above and considering our 3D modeling environment, a rough conclusion could be...
made that online 3D worlds will become more common and virtual worlds will contain more and more realistic aspects. So in this paper, we propose the 3D online OpenSim virtual world as a promising environment for modeling, testing, and learning. In OpenSim, simple and regular 3D objects can be created easily, and anyone can interact with the environment as an avatar.

The contents of this paper are arranged as following: first the necessity of reality-virtuality fusional environment is discussed; after that, the multi-user collaborative online 3D modeling platform is introduced, containing different modeling methods for various complex objects; and finally, some experiments based on this online platform will be shown, providing the basis for future work.

1  The necessity of reality-virtuality fusional environment

Representation is the conceptual core of an information system. A representation scheme determines data elements and their associations, which an information system can use to hold data and depict reality. The map metaphor fits well with cognitive models that we use to acquire slowly changing large-scale environments, and maps are always the most efficient and effective way of communicating metric properties of larger scale places, especially configurations. GIS representation has followed the map metaphor to portray reality as a 2D/3D static world. Our virtual campus provides 3D representations of real The Chinese University of Hong Kong (CUHK), both outdoors and indoors. However, the real world is in flux and geographic processes are dynamic, yet the 2D/3D models represent only a single instance of the scene, namely the moment when the images used to create them were actually collected. Augmented Reality (AR) or Mixed Reality (MR) includes both virtual reality and real-world elements, dealing with the combination of real-world and computer-generated data, but is always restricted to head-worn or other wearable/mobile devices which are not so convenient tools for data acquisition.

Nevertheless, GeoSensor Networks provide us an opportunity to incorporate the temporal aspect into the geographic environment. With the numerous distributed sensors everywhere in the real environment, the evolution of spatial objects or geographic process can be captured by them, and real-time dynamic monitoring of geographic phenomenon will be realized.

The ability to manipulate, interpret, and store information about changing geographic environments is a critical human cognition ability. Models of the cognitive aspects of dynamic spatial representations are necessary for understanding temporal and spatial changes in spaces or maps, for the manipulation of temporal geographical data, and for navigation through changing space. Additionally, geospatial cognition of dynamic geographic phenomena may be influenced by animated and dynamic external representations of the physical world (e.g., interactive “map movies” or dynamic virtual worlds). An animated and dynamic virtual environment is offered to enhance or augment the cognition to the real world of a user.

Based on our online 3D modeling platform, with the real-time data extracted from reality by GeoSensor Networks, the virtual campus and the real campus can be merged together, and enhanced by their ability to mutually reflect, influence each other.

To sum up, we actually live in the real world. In order to know that world better, many models were built to construct a virtual world. Much work has been done to achieve this goal. However, the real world is not exactly the same as the world of human seeing and knowing; there are limitations to human understanding of the real world, requiring the assistance of virtual environments if greater understanding is to be realized. The virtual world is not exactly the same world of reality. Either the virtual reality or the mirror world is also limited representations of the real world. So in the future we would like to put emphasis on the middle zone between the real world and the model world (Fig. 1).

Fig.1  Real world and virtual world
2 Multi-users collaborative online 3D modeling platform

2.1 System architecture

In this paper, the virtual campus environment is defined as an avatar-based, explicitly geographical, immersive, and sharable 3D visual platform. The virtual campus server is deployed as an HTTP request and response application from a UserServerURL with all the required components for virtual scene construction and application extensions. The user-account service, user’s asset service, region grid control, and other services are managed handily by the grid manager server model which leverages the system of remote connectors and services. Also, the region server communicates with the grid manager server and runs multiple region simulators on different distributed machines. The whole virtual campus scene is based on the OpenSimulator server, consists of the ‘grid’ in which the terrain domain is divided into regions of meters. As shown in Fig.2, there are 36 regions in the virtual campus of CUHK and they are managed by three distributed region servers where the data of DEM and 3D geo-objects are stored. Each region has a unique ID for grid index such as v23, v31, etc. Based on the OpenSim viewer, the virtual campus client viewer can render the 3D scene and represent dynamic interactions. And users may modify the topography of land region via the virtual campus viewer; here, each region could be operated as a work area related to the collaborative 3D modeling. When the models of each work area are collaboratively completed, dynamic applications can also be implemented and are further combined to form the whole system.

2.2 Collaborative online 3D modeling

The whole experimental platform is constructed through collaborative work in a distributed online 3D environment to support object reconstruction with more than one modeler, based on the common database clusters. All the modelers access the system from different places for co-building objects, modifying the virtual environment through synchronous or asynchronous cooperation, creating shared standard geo-models such as bridges, trees, building, and shared inventories and repositories of textures via multiple avatars toward collaborative tasks. The user interface can also facilitate users to query information, develop 3D avatar-based communications, and carry out scientific experiments.

In the online platform, 3D objects can be either simple boundary representations such as planar faces and straight edges or complex volumetric representations with elaborate interior structures. Based on OpenSim, a collaborative modeling approach oriented to multiple Levels of Details (LoD) for 3D content creation is provided, supporting the full view of the whole scene of the virtual campus from the simple bounding appearance to real 3D interior layouts (Fig. 3).

- **Primitive-based models:** 3D models are represented or assembled by basic primitives such as box, cylinder, prism, sphere, torus, tube, and ring. The basic primitives own their locations, shapes, and appearances by means of varying the parameters such as position, scale, rotation, shape, cut, hollow, etc.
- **Integrated CAD models:** Computer Aided Design (CAD) is mainly used for detailed engineering of 3D models with a high degree of accuracy. On the
platform the existing CAD data could be used and it makes the geo-models more elaborate and vivid.

- **Sculpted method**: The sculpted method is a special type of complex surface modeling to create smooth/curved surfaces like boats, sculptures or any other object from the absolute textures. Each sculpted prism is a 3D mesh created from a texture array, of which each element corresponds to the information of a control point and the RGB values stored as $x$, $y$, and $z$ coordinates, respectively.

Based on these flexible modeling methods, multiple users can work online at the same or different times, places to construct 3D architectures or to solve complex geo-problems.

### 3 Framework of the reality-virtuality fusional campus environment

In part 2, the detailed online 3D modeling platform has been introduced, and as we analysed in the section of the necessity for a reality-virtuality fusional environment, sensors provide us the opportunity to merge/link the reality and virtuality because various sensors can obtain geographic phenomena and processes both seen and unseen in real-time. The sensor data integrated into modeling and visualizing, or deployed for analyzing in real-time or near real-time in the detailed 3D virtual world, constructs a reality-virtuality fusional environment. This environment not only takes advantage of the characteristics of the virtual environment but also provides some elements of real information about the physical world for people to perceive and understand.

The distribution of some environmental monitoring sensors are planned across the real CUHK campus for monitoring geographic phenomena such as noise and polluted air and for obtaining other information such as video or sound in real-time. Fig. 4 shows the abstract vision of the whole framework; there are air quality, noise, temperature, energy, and other sensors which can be used for collecting real-time data. These sensors are connected to a network which is available to the users who access the web. Sensor data is managed by a database which is also connected to the network. Through our ISEIS GISSLCloud, and based on the virtual CUHK campus platform, researchers may predict a phenomenon is going to occur or model a phenomenon by models in the VGE environment, and thus the university staff and students can know the environmental condition of our campus better when they use the system.

In the framework, the modeled campus environment is regarded as the virtual part of the VGE campus platform, while the real-time visualization and representation of the monitoring data can be taken for the real part. People may not see the air condition intuitively in the real world, but, in the virtual campus the monitoring data can be visualized in different colors, shapes or types, which will help people to cognize the phenomena more easily. With the real-time visualization of the monitoring data in the existing virtual campus, the whole virtual campus platform can be regarded as a reality-virtuality fusional environment.

![Fig. 4 Framework of the reality-virtuality fusional campus environment](image)

### 4 Preliminary experiments based on the platform

Based on this multi-user collaborative online 3D modeling platform, the static and real existing objects such as buildings, trees, lakes, and even the interior of the buildings are modeled corresponding to the campus of CUHK (Fig.5), and taking into account the necessities of reality-virtuality fusional environment, the virtual campus can be considered as a useful tool for scientific research, experiment, and management, etc. Some preliminary experiments based on the platform to link the physical campus and virtual CUHK with sensors are shown.
4.1 Streaming videos and live broadcasting

As a common media, video can provide people more realistic and easily perceived information, but also can be acquired, saved and distributed in simple ways. To make the virtual campus closer to the real world, we provide real video information in the system, including both historical and live videos.

In this experiment, a big screen was put in the Chung Chi College (Fig.6), which shows the introduction of CUHK by playing streaming video from the Internet. The URL of the video was obtained from the web page of CUHK and the Linden Scripting Language\(^1\) was used to play the video in OpenSim. This experiment can be used to introduce the university to strangers who come to the campus, such as the new students’ families, where he/she can view the real CUHK besides the various complex models in the system.

Another experiment realized live broadcasting in the virtual system (Fig.7). The users may perceive the real living atmosphere while immersed in the virtual environment. To acquire the video data both historical and real-time, a camera such as the integrated web camera in a notebook, computer camera, and digital video or even mobile phone must be connected to the system and then the real video information can be integrated to the virtual campus.

In the experiment, a common web camera connected to the Internet was used to obtain the real-time video streams, a free software transfers the video streams to QuickTime (a player developed by Apple Inc.) supported formats for OpenSim only provides support to these types of videos. Then, in the virtual campus users can see the live broadcasting of a certain place where the video sensor is located. However, due to network delay, the broadcasting lags a little compared with the real situation.

4.2 On-going work

Noise is an important factor in the campus, and a noise map can show the noise distribution of an area. In this on-going work, mobile devices were used to monitor the noise value around our Basic Medicine Science Building and these mobile devices can also get the position information and then send to the system. With processing and multiple means for visualization and statistics of the noise data on the online platform, the virtual campus will represent the unseen noise which exists in reality. In the future it will become essential to connect a smart campus with various sensors (air quality, temperature and humidity, etc.). These sensors will be distributed to monitor these unseen phenomena based on the framework of the reality-virtuality fusional environment.

We have modeled the monitor sensors in some places in the virtual campus environment (Fig.8) where the real sensors are planned to be distributed. These devices will simultaneously capture and aggregate
data from physical sensors in the campus like noise, temperature, humidity, and even real-time video images that can be streamed into the VGE system. We are also planning to represent the sensor data value (such as LED numeric display, curve chart or graphics, etc.) in the virtual environment simultaneously.

5 Discussion and conclusion

This paper provides an online 3D platform based on OpenSimulator, which corresponds to the CUHK and built a virtual campus environment with reality-virtuality fusional information. From the analysis and preliminary experiments, some ideas may be derived that: the online collaborative modeling and environment is the trend of the virtual world; abstract or static model world is not the so-called “mirror world” or “metaverse”, because besides these models, there is still a lot of unseen or non-observed phenomena in the real world; and sensors (both professional and other portable mobile devices) can link/bridge the physical world and the virtual environment.

However, this paper is only a preliminary exploration. For long-term consideration, we plan to make the virtual campus platform cross the real-space and virtual-geographic experience for estimating and predicting the long-term human settlement environment in campus area, and thus contribute to a better understanding of geo-spatial cognition and the development of smart city management in Hong Kong. This is because the CUHK campus can serve as a template for Hong Kong’s natural and social environments with hilly terrain, complex buildings, composite road networks, unique geographic phenomena, and social behaviors.

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