3D City Model Visualization in Decision Theater

A framework for multi-dimensional journey through time

Yoshihiro Kobayashi
Arizona State University, USA
http://www.public.asu.edu/~ykobaya

This paper introduces an ongoing project that visualizes and simulates 3D city models in a communicating space called Decision Theater (DT). The background of DT and objective of the project are explained. Also, the framework of the project including database development, 3D city modeling, interface development, and applications is introduced.

Keyword: *Virtual Reality, 3D city modeling, GIS, computer graphics*

Introduction

Recently various 3D city models are developed and used in the industries of movie, game, and information technology (IT). For example, Hollywood movies like King Kong[1] adopt extremely precise city models for reality (CG Architect, 2006). The 3D city model developed with Geographical Information System (GIS) such as Google-Earth[2] is widely used nowadays as well. However, there are still some problems when we think of 3D city models as a tool for decision-making. The main problem is that components of a 3D city model such as buildings, trees, and streets are almost always static and cannot correspond to various requests from decision makers flexibly and dynamically. For example, unless the components have temporal spatial information on their own, it is impossible to determine when they start to exist or how long they are there. In fact, most of the 3D city models are created from scratch each time the need arises at present.

A great variety of Virtual Reality (VR) environments that visualize 3D contents are currently researched and developed especially in academic institutes such as Sasada (1998) Laboratory at University of Osaka. These VR environments include 3D city models for architectural and urban planning and human organic models for medicine. In addition to developing the 3D contents, the VR environments are used to visualize the results of scientific simulations. Unfortunately, however, most of the VR ideas are not quite utilized, and the theaters to exhibit these VR environments usually do not have many repeating visitors. In order to make good use of the VR theaters, the framework to attract more people to the VR environments needs to be established. In particular for the 3D city models, the VR theater should be a place that decision makers from various fields, such as politicians, realtors, stakeholders, and designers, get together and make decisions while evaluating architectural designs and simulations.

The following are indispensable in order to attract the decision makers to the VR environment: 1) a database for 3D city models that supports temporal spatial information, 2) an interface for the VR environment that corresponds to various requests from decision makers flexibly and dynamically, and 3) a VR environment where people gather and make deci-

[1] www.kingkongmovie.com: Jan 2006

[2] http://earth.google.com: May 2006

sions practically and continually.

Background

Phoenix City

Phoenix is the capital city of Arizona and has been one of the most growing cities in the US. The population of Phoenix increased from 0.9 million to 1.3 million in 1990-2000. Currently, Phoenix-Mesa metropolitan area has about 3.3 million people, and Phoenix is considered as the 5th biggest city in the US[3]. However, more than 30% of downtown area is vacant land or used just for parking lots. In order to improve the inefficiency of land use, a project to construct many new buildings in downtown Phoenix has been planned[4]. Arizona State University (ASU) also plans to build its new campus in the downtown area[5]. It is expected that government, university, and industry will get together and make Phoenix a more attractive city.

ASU Decision Theater

In 2005, the ASU Decision Theater (DT) was established to provide the advanced visualization environment that will enable decision makers and other specialists to observe the consequences of their actions[6]. It has a space of about 8,000 square feet that includes a 260-degree immersive virtual reality (VR) environment and several other rooms for facilitating various decision-makings. Technically, a Linux based 9-node cluster with high-end 3D video cards is used for the stereo presentation and 40-node dual-processor computer cluster supports the rendering engine and complex computation. The main theater can display 7 screens with over 10 million pixels at the same time using 7 channels of 1400 x 1050 resolution, which is one of the highest performing VR environments

Problem Statement

The objective of this project is to develop the system that facilitates decision-making and to make the ASU DT the place where decisions on various problems in Phoenix can be made practically and continually. In order to realize this idea, the framework of database development, 3D city modeling, interface development, and applications is introduced.

Framework

Database Development

The temporal and spatial database of 3D city model is developed. In the model each component such as building, street, and tree has geographical reference information and time stamps. The geographical information is used for integrating existing GIS database, and the time stamp is used to represent the existing periods. For example, a building existed from 1920 to 1950 has the time stamps of 1920 and 1950, and the 3D object is shown only when the user specifies a year between 1920 and 1950.

3D City Modeling

Finding a way to create 3D city model for visualizing the past, current, and future scenes effectively and efficiently is most important in this project. Although there are many different methods of creating 3D city models, the approach to generate 3D city models from aerial photos using photogrammetry is used in this project (Chen et al, 2004; Früh and Zakhor, 2004; Pennington and Hochart, 2004). This approach can save time and cost because it enables to extract building geometry and textures at the same time. Figure 1 shows the model of downtown Phoenix created with this approach. In creating the model, one vertical shot and several oblique shots of downtown Phoenix were taken at the altitude of 6000ft by a regular aerial camera with 9″x 9″ films. Each film was

[3] http://en.wikipedia.org/wiki/Phoenix,_Arizona: 2006

[4] http://www.coppersquare.com/business/: 2006

[5] http://phoenix.gov/downtown/asu.html: 2006

[6] http://dt.asu.edu: May 2005

scanned with 2000 dpi. By using a commercial off-the shelf photogrammetry tool, Nverse Photo 2.7[7], the 3D city model of downtown Phoenix covering one square mile including more than 700 full-textured buildings was created within 2 days by one person. The past and future models will be created based on this current model. The past models will be created manually if the stereo pairs of aerial images are not available. The future models will be generated based on the output from UrbanSim, which is an agent-based simulation tool to estimate the future population pattern (Waddell, 2002).

Interface Development

The interface for communicating the data between the screen at the ASU DT and the database is developed by customizing an existing VR simulation package, UC-win/road[8]. The package is chosen because it is developed based on OpenGL technology, and the application programming interface (API) for customizing the package in C++ is available. In addition, since the package has already implemented several tools for traffic simulations, it is possible to visualize the traffics in the past, current and future models with a small customisation. It is required to implement additional functions to control the temporal spatial information for visualizing the model of specific past year and to generate virtual models from population patterns for visualize the future models.

Applications

The following are example applications of the system at the ASU DT.

1. Historians visit the ASU DT repeatedly for investigating historical changes on landscape and urban development. They can observe Phoenix city in the past by flying through the city model and by driving on any street.
2. Using the current city model, a variety of traffic simulations can be created. For example, the traffic conditions are simulated when several lines are closed for constructing new buildings in downtown. Another example is when an emergency happens and all of the traffic lights are out of order for a minute.
3. Since a building is modeled with temporal spatial information in this system, the landscape changes can be observed simply by specifying a specific year. For example, the building that will be built in 2008 can be viewed by setting a year after 2008.
4. It is possible to visualize the scenes of Phoenix in 2100 and generate the alternative scenes by changing the input parameters in the UrbanSim such as land use, household income, and freeway patterns.

Summary and Future Works

The paper introduced an ongoing project to develop a decision-making system for Phoenix, Arizona, and the ASU DT that has a VR immersive environment. . The framework of this system including database development, 3D city modeling, interface development, and applications was explained.

It is considered that this system is applied to the following areas in the future.

1. To realize a fully automatic car navigation system (in which the traffic is fully automatically

Figure 1.
A screen shot of demonstrating 3D city model at ASU Decision Theater

[7] http://www.precisionlightworks.com: 2006

[8] http://vr.forum8.co.jp/english/: 2006

controlled by computers) by extracting the real traffic amount with camcorders and linking the data to this system.

2. To study about the decision-making using tangible interfaces at VR environments.

Reference

Chen T., Shibasaki R. and Tsuno K.: 2004, Orientation Strategies of Airborne Three-Line Scanner STARIMAGER's Imagery with Minimum Ground Control, International Archives of Photogrammetry and Remote Sensing, Istanbul, Turkey.

CG Architect 2006, 'Interview with Chris White on King Kong', [Online], Available at http://www.cgarchitect.com/upclose/article1_CW.asp

Früh C. and Zakhor A.: 2004, Automated Method for Large-Scale, Ground-Based City Model Acquisition, International Journal of Computer Vision, 60 (1), pp. 5-24.

Pennington H. and Hochart S.: 2004, Honolulu, Hawaii Building Footprint Geo-Database Project: 3D Urban Visualization, Proceedings of ESRI User Conference, San Diego.

Sasada T.: 1998, The Sasada Lab, Department of Environmental Engineering Graduate School of Engineering: ACADIA Quarterly, 17(4), pp. 5-6.

Waddell P.: 2002, UrbanSim: Modeling Urban Development for Land Use, Journal of the American Planning Association, 68(3), pp. 297-314.