WORLD8

International Working Group for New Virtual Reality Applications in Architecture

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ABSTRACT: This paper introduces the activities of World8, an international working group on virtual reality, and demonstrates the group's developed VR applications in architecture. Group members come from eight universities around the world, including the United States, the United Kingdom, Japan, Chile, Canada, Egypt, and the United Arab Emirates. The main objective is to develop a research framework for collaboration between architectural schools and a software developing company. Specifically, the group is looking to create new applications for VR visualizations of urban settings with dynamic agents such as human and vehicular traffic. Models developed by these members are explained, and the project is reviewed based on survey results.

KEYWORDS: Virtual reality, 3D city modeling, agent-based simulations, international project, education

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RÉSUMÉ : *Cet article présente les activités de World8, un groupe de travail international sur la réalité virtuelle, et présente les applications VR en architecture développées par le groupe. Les membres du groupe proviennent de huit universités à travers le monde, comprenant les États-Unis, le Royaume-Uni, le Japon, le Chili, le Canada, l'Égypte, et les Émirats arabes unis. L'objectif est de développer un cadre de recherche pour la collaboration entre les écoles d'architecture et une entreprise de développement de logiciel. Le groupe cherche à créer de nouvelles applications pour la visualisation VR des zones urbaines avec des agents dynamiques, tels que l'humain et la circulation des véhicules. Les modèles développés sont expliqués, et le projet est examiné sur la base des résultats.*

MOTS-CLÉS : *Réalité virtuelle, modélisation 3D de la ville, simulations basées sur des agents, projets internationaux, éducation*

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1. INTRODUCTION

VR technology has been commonly used since 1990s. Online VR technologies, such as VRML (VRML 2009), Shockwave (Adobe 2009), X3D (X3D 2009), and Virtools (Dessualt System 2009), have been used in many commercial web sites. VR devices, including mount displays, tangible interfaces, and touch sensor gloves, have also been developed. In architecture and urban planning, most VR technologies have been used just to visualize static 3D cities and buildings. Not only does it take significant time and labor to make 3D objects such as buildings and streets, but the effect of polygon-heavy models in real-time simulation limits the size of large city models. However, in order to visualize more realistic VR city scenes and achieve usable results from these simulations, it is necessary to not only construct the buildings, but to also include traffic and human models as intelligent agents.

The current academic framework in architectural studies often thwarts VR research and development. Most universities have only a few researchers in computation, so it is difficult to find time for discussion and collaboration. Conferences enable the sharing of conceptual knowledge, but not VR technologies. In addition, there are many different VR tools, so most researchers use different platforms to develop VR data and tools. As a result, it is difficult to test each others' models, and it is hard to share a combination of knowledge and skills. This is a problem from the point of view of knowledge-accumulation.

This paper introduces a project, World8, which has been in progress for about a year (2007-2008). The vision, mission and values of the project are explained in the following section. As a part of this project, eight team members used the same platform and VR package and shared their data and experiences during the modeling and development process. The VR package is introduced in the Section 3, and the developed models are explained in the Section 4. A review of this project is explained in the Section 5, and conclusions and future works are described in Section 6.

2. VISION, MISSION, AND VALUES

2.1. Vision

World8 was organized in 2007 with the goal of exploring a new research and development framework to share information between academics and professionals involved in architecture and urban planning. The objectives include providing more opportunities for group members to discuss VR applications and demonstrate their ideas by making VR city models. All members used the same platform and software package.

Topics include: the integration of VR city models with current technologies such as GIS, Google Earth, and traffic analysis in VR environments, the reduction of modeling time and labor, the visualization of traffic and human models in real-time, and the educational and historical framework developed around VR technology implementation.

2.2. Mission

World8 has held three events over the past 12 months. The first meeting took place, in Tokyo, Japan in November 2007 and served to introduce the participants and their proposed projects. The next day the members were invited to a VR contest held by the software developing company. At the contest, the practical applications of the VR software were demonstrated and judged. After the event, a license for the software package was given to each member.

In August, 2008, we held a three-day hands-on workshop on the relevant software at a university in US. On the first day, basic processes for VR city modeling with the software solution were introduced. On the second day, advanced techniques were discussed for processes including: 1) modeling terrain data from DEM data, 2) generating streets from GIS shape files, 3) importing 3D buildings created in the other packages into the current VR environment, 4) creating animated human models, and 5) developing plug-in computational tools in Delphi 2007 (CodeGear 2009). On the last day, each member made a 20-minute presentation and shared new ideas for VR applications.

During the most recent gathering, each member demonstrated their own VR model and explained their concepts. This 2nd VR symposium was held on November 19, 2008 at the Tokyo Convention Center with more than 300 guests in attendance.

2.3. Values

This project was implemented to propose the following values: 1) Providing more opportunities to discuss VR applications in architecture and urban planning. This would allow for a better evaluation of an application's benefits and problems, 2) Developing methods to reduce time and labor for creating VR city models, and 3) developing a new VR application with dynamic agents such as traffics and human models. Using the same platform, we would be able to reuse objects and ideas developed by the other members. As a result, we would be able to share new knowledge and techniques on VR city modeling.

3. COMMON PLATFORM: UC-WIN/ROAD

UC-win/Road is a VR modeling and visualizing software package developed by Forum8 Co. Ltd. (Forum8 2009). The software is mainly designed for civil engineers to visualize road and street networks including individual lanes, traffic signals, intersections, bridges and tunnels. These are displayed in a VR environment using a real-time rendering engine. UC-win/Road has the ability to generate traffic as intelligent agents, for example, stopping at red lights and changing speed depending on the positions of nearby cars. In using this software package, it is possible to create precise road network models and visualize them real-time.

The process of VR city modeling in UC-win/Road can be divided into three steps. The first step involves importing terrain data and draping it with satellite imagery. The terrain data can be imported from GIS shape files, andXML files, or DEM image files (LandXML 2009). The second step involves creating road networks. Each road is created from a list of cross-section, and these sections can be edited within the package itself. A complicated intersection can also be modeled within the same interface. The final step includes adding 3D objects such as traffic lights, buildings, and trees.

This software solution includes these visualization functions as basic tools. It enables the editing of visual options such as day or night lighting, and weather conditions such as rain, snow, and fog. By preparing several 3D data sets, it is possible to change the models in real-time. It also possible to script scenarios with events, and the alter the visualization contents and model movement. Additionally, users can take a drivers' perspective from within cars, and drive around the VR model.

4. MODELS

This section introduces the models developed by World8 members. An outline of each model is briefly explained, but details and algorithms are not included as they are beyond the scope of this paper.

4.1. Animated human models in a VR city Model

FIGURE 1. *HUMAN MODELS CROSSING AN INTERSECTION: A SCREEN SHOT IMAGE OF A SIMULATION TOOL (LEFT), AN ANIMATED 3D CHARACTER MODEL (MIDDLE), AND A SCREEN SHOT IMAGE OF 100 PEOPLE CROSSING IN A VR MODEL.*

Figure 1depicts the process of generating animated human models in a VR environment. The left image is a screen shot of an implemented simulation tool that calculates the positions of people for each step in crossing an intersection in Shibuya, Tokyo. Each human model is programmed in Java as an agent that can avoid collisions with other people. The simulation tool exports the position data as a text file. Each line of text represents the XY position for a model in each animation frame. For example, a human model indexed as "15" located at (100, 200) in animation frame 3000 is represented as following:

100 200 15 3000

The middle image shows a screen shot of an animated 3D character model created as an MD3 file in 3DS MAX. A plug-in tool, implemented in Delphi 2007, reads the position files and imports each MD3 model into their given positions in the VR model. The right image shows a screen shot of a VR model with 100 people crossing the intersection.

4.2. Stochastic city generation in VR

FIGURE 2. *STOCHASTIC CITY GENERATION: THE GENERATED TERRAIN (LEFT), THE GENERATED HOUSES ON THE TERRAIN (MIDDLE), AND A SCREEN SHOT IMAGE OF THE VR MODEL WITH THE GENERATED STREET NETWORK (RIGHT).*

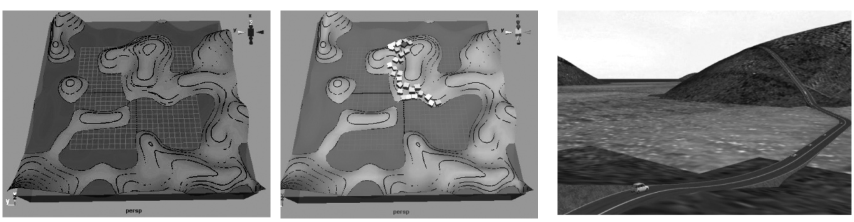


Figure 2 depicts the process of importing the generated landscape into a VR environment in real-time. First, terrain data is generated by defining the height of some points randomly. Second, houses are generated one by one stochastically with some constrains. Street networks are also generated to connect one village to another. A procedural modeling tool is implemented in Maya using MEL script. This tool also exports terrain data and street networks to the VR environment as a LandXML file, which is supported by UC-win/Road.

4.3. VR modeling using form-based code

FIGURE3. *VR MODELING USING FORM-BASED ODE: THE INPUT ZONING IMAGE (LEFT), A SCREEN SHOT OF THE PROCESS IN 3DS MAX (MIDDLE), AND A SCREEN SHOT IMAGE OF VR CITYSCAPE MODEL (RIGHT).*

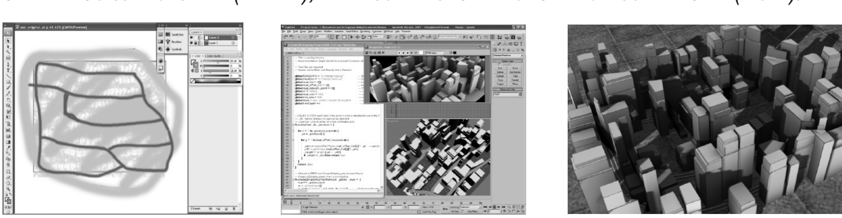


Figure 3 depicts the process of generating a VR cityscape model using Form-based code, one of the design methods used practically in urban planning. In order to generate VR city models based on this code, an image is input using specific colors that correspond to the code. A tool that generates 3D buildings and streets is implemented in 3DS Max using Maxscript. Each building is rendered using an advanced global illumination rendering package, V-ray, and is exported as a 3DS file with a baked texture. A plug-in tool to import the 3DS files into the VR environment is implemented in Delphi 2007 with a UC-win/Road SDK.

4.4. VR City modeling using GIS shapefiles

FIGURE 4. *GIS: THE ZONING DATA (LEFT), THE SCREEN SHOT OF READING A GIS SHAPE FILE INTO UC-WIN/ ROAD (MIDDLE), AND THE SCREEN SHOT IMAGE OF VR CITY MODEL (RIGHT).*

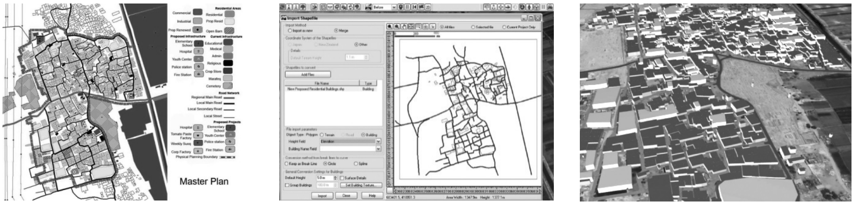


Figure 4 shows the process of VR city modeling using GIS shape files. One of the World8 members is involved in a practical project in Egypt. By using a built-in function to import GIS shape files, several different plans are visualized in the VR environment. One advantage of using VR technology in urban planning, as compared to 3D-GIS or Google Earth, is that plans can be visualized in conjunction with different traffic patterns, and times of day.

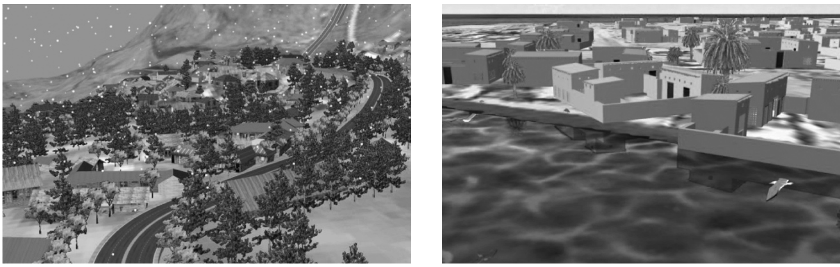
4.5. VR city model with LRT

FIGURE 5. *VR CITY MODEL WITH LRT: PROPOSING LRT SYSTEM IN MONTREAL, CANADA (LEFT), AND THE PROPOSING LRT SYSTEM IN SAKAI, TOKYO (RIGHT).*

Figure 5 shows the two VR city model with LRT. As explained in the Section 3, the VR package that we used in the project can control the traffics including automobiles and trains. Therefore, it is useful to visualize the future urban scenes with the new traffic systems, especially with LRT system.

4.6. Other models

FIGURE 6. *VR CITY MODELS: SKY RESORT DEVELOPMENT (LEFT), AND HISTORICAL VILLAGE MODEL (RIGHT).*

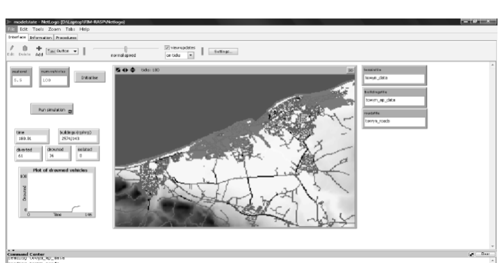


Another group member created a practical project to develop a new street in a ski resort in Chile. Currently there is one main street through the resort town. As the street has more than 40 intersections, there are problems with traffic congestion. A new proposal for constructing a detour route would reduce the number of intersections to 14.The resort is located on the steep slope in a mountain, so it is difficult to imagine the plan without 3D models. By visualizing traffic on the new proposed route, it is easier to analyze the plan and predict what traffic congestion would be like on the slope. Terrain data and the buildings are modeled in 3DS Max. A plug-in tool that converts the polygon-mesh data to LandXML formatted terrain data was used. (See section 4-1)The VR visualization was modeled in a few hours.

The second image in Figure 6 shows an existing village in the UAE. One of the important applications of VR is education. The satellite images are imported from Google Earth Pro, and the buildings are modeled in advance with SketchUp. After a few hours, the SketchUp building models are imported into the VR package. The 3D animated animals who habitat the area are also included in order to better understand the site.

Another proposal from a World8 member included the application of VR technology to a scientific research framework for visualizing flood impacts and evacuation traffic patterns in the UK. The idea and outline were introduced in the workshop, but the model was not yet developed in the limited timeframe. The concept is shown in Figure 7.

FIGURE 7. *SCREEN SHOT IMAGE OF AGENT-BASED MODEL TO SIMULATE FLOOD AND TRAFFIC IMPACTS.*



4.7. Summary

During the World8 project, several plug-in tools were implemented and demonstrated. Their functions included the generation of: terrain data from mesh polygons created in Maya and 3DS Max, street models from a list of control points, cityscape models automatically from image files that define street networks and zoning, and 3D animated character from text files specifying locations. The advantages of using GIS shape files in a practical urban planning project were demonstrated. Useful applications for visualizing the proposing traffic systems in a VR environment were introduced through several models

5. CONSIDERATION

5.1. Review of project

This section reviews the project, using results from a survey taken of World8 members after the 2nd symposium. The Table 1 and Table 2 list the questions about the project and software, as well as the average points allotted by members. . Members answered each question by selecting on a scale from 1 to 5; 1 = very positive, 2= positive, 3= neutral, 4=negative, and 5 = very negative.

Overall, the project was evaluated very positively. The three events were evaluated as very well-organized and scheduled. Several difficulties in using the software packages were pointed out, and the company accepted the proposals and promised to improve the interfaces in the next version.

TABLE 1. *PROJECT REVIEW.*

	Question	Average
1	It was useful to attend this project	1.1
2	I could get new knowledge and skills from this project	1.1
3	I am satisfied with my result and model in the project	1.8
4	The events were well organized	1.0
5	I would like to attend this project again in the next year	1.1
6	I would like to get more resource to hire a student	1.2
7	I agree with the idea to add 8 more members	1.5
8	I agree with the idea to have an additional symposium in Spring	2.1
9	I can be involved in developing the workshop this summer	2.5
10	I can be involved in developing our Web site	2.1

TABLE 2. *SOFTWARE REVIEW.*

	QUESTION	AVERAGE
1	Overall, UC-win/Road was easy to use	2.0
2	The interfaces are user-friendly	2.4
3	The modeling process is clear	2.3
4	There was a good help and support	1.6
5	I have several new ideas using this software	1.6
6	I am interested in developing tools using SDK and Script	2.3
7	It was easy to install and set up the software	1.6
8	How many hours did you used the software 1: >500, 2: 500-100, 3: 100-50, 4: 50-10, 5: <10 hours	2.4

5.2. Consideration

The following are my comments as the project chair. As long as I know, this is the first project that has gathered researchers from eight universities throughout the world to discuss one specific design and computational topic in architecture. The project was a great success with very positive feedback from both the members and the sponsoring company. For several decades, many ideas and methods have been introduced every year in conferences on design and computation in architecture. However, most of the projects are standalone, and rarely refer to the other research projects (as is often done in other fields such as construction and structural research.) This project has the potential to add more opportunities for researchers to share their skills and knowledge.

There were some difficulties in managing this project. The main problem was difficulties in communicating with all the members at the same time. The members are from 7 different countries, so it usually takes two or three days to receive all the responses to a sent e-mail. Another difficulty was the difference in model creation progress. Some researchers are very familiar with developing VR city models, and some are not. This issue was solved by the support from the sponsoring company and two research assistant students who are expert users of UC-win/Road.

The greatest benefit from the project was that each member could understand how easily a VR city model could be generated or created by sharing the developed plug-ins. It takes a few hours to assemble 3D objects in a VR environment, and it takes only a few minutes to generate 3D cityscapes using the scripts. Animated human models were also visualized in VR city models using the developed plug-in tools. Objects from different kinds of simulation tools could be imported with a simple formatted text file

6. CONCLUSION AND FUTURE WORKS

This paper introduced the activity of a worldwide working group on VR applications in architecture and urban planning. The VR city models developed by World8 group members were briefly demonstrated. Several computational plug-in tools for a VR software package were also developed. Throughout the three events held over the past 12 months, members were able to share skills and knowledge about VR city modeling, as well as develop plug-in tools.

Future plans include 1) development of a web site that shares skills and knowledge on VR city modeling and visualization with the public, 2) increasing the number of members, and 3) developing more advanced models as a group.

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