A 3D REAL-TIME VR(VIRTUAL REALITY) SIMULATION SYSTEM

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ABSTRACT: *This paper presents a 3D real-time VR (Virtual Reality) Simulation System on a PC and illustrates its use with a real world case study. Until recently VR Systems required Mainframe or Work Station class platforms. We have developed a VR System on a PC that can create virtual 3D scenes using simple operations. With this system, terrain data can be loaded and objects such as Roads, Buildings, Trees etc. can be created and positioned, so that the real 3D space can be reproduced on a PC. This virtual 3D space allows simulation in real time of driving on roads and flying in the sky.*

Keywords: *VR; virtual reality; real time; simulation; PC; 3D; OpenGL; Windows; Road*

1. INTRODUCTION

Until recently virtual reality systems required mainframe or workstation class platforms, but with the advances in PC and especially 3D hardware technology, writing these applications on personal computer hardware has become feasible. This new hardware and graphics API's such as OpenGL give the software developer the tools to create VR applications for commodity PC platforms that can match or exceed the performance of earlier mainframe or workstation systems. Our real-time VR software (UC-win/Road) running on inexpensive hardware allows the engineer/designer to cheaply explore design options and present visually the impact of a design prior to construction.

The main benefit of using a computer to generate 3D images is it is cheaper than constructing miniature models. With models stored in a computer it is possible to view scenes from any angle, and even "walk" though a scene and view it as if you were really there.

Other uses for UC-win/Road include:

- Residential consensus (public involvement) for public works
- Assessing the design or color of structures (like bridges)
- Aesthetic appearance of roads and structures
- Assessing the visibility of road signs
- Impact on environment

2. DESIGN GOALS

The ultimate goal of UC-win/Road is to provide a photorealistic real-time virtual environment where a designer can create and modify an artificial world which can then be presented to a client. UC-win/Road is not a full fledged traffic simulation package nor does it provide engineering calculations; it is solely concerned with creating visual imagery.

To meet the above goal, we have set the following objectives: a terrain area must be able to be selected and automatically generated; simple definition of roads and highways should be possible; and details such as road signs, buildings, trees etc should be easily added into the

world. To truly make this virtual world appear as it really is (or we want it to be) it must also be able to model pedestrians and simulate road traffic.

Not only must the scene be easily created, it must also be able to be simply displayed and presented to a viewing audience.

3. CURRENT STATUS OF UC-win/Road

Unfortunately creating photorealistic real-time virtual worlds is not yet possible, but we are getting closer all the time as video software and hardware technologies improve. Currently UC-win/Road uses the OpenGL API to give us hardware accelerated rendering of textured polygons on modern video cards.

3.1. The Terrain

UC-win/Road provides a 50m grid terrain map of Japan [1]. Areas from 10km x 10km to 20km x 20km can be selected and loaded into a scene (Figure 1).

Street map data for parts of Osaka and Tokyo are also provided [2] to allow the terrain texturing to be changed to make road placement easier. Satellite and aerial photographs can also be used to texture the terrain to achieve a more photorealistic appearance.

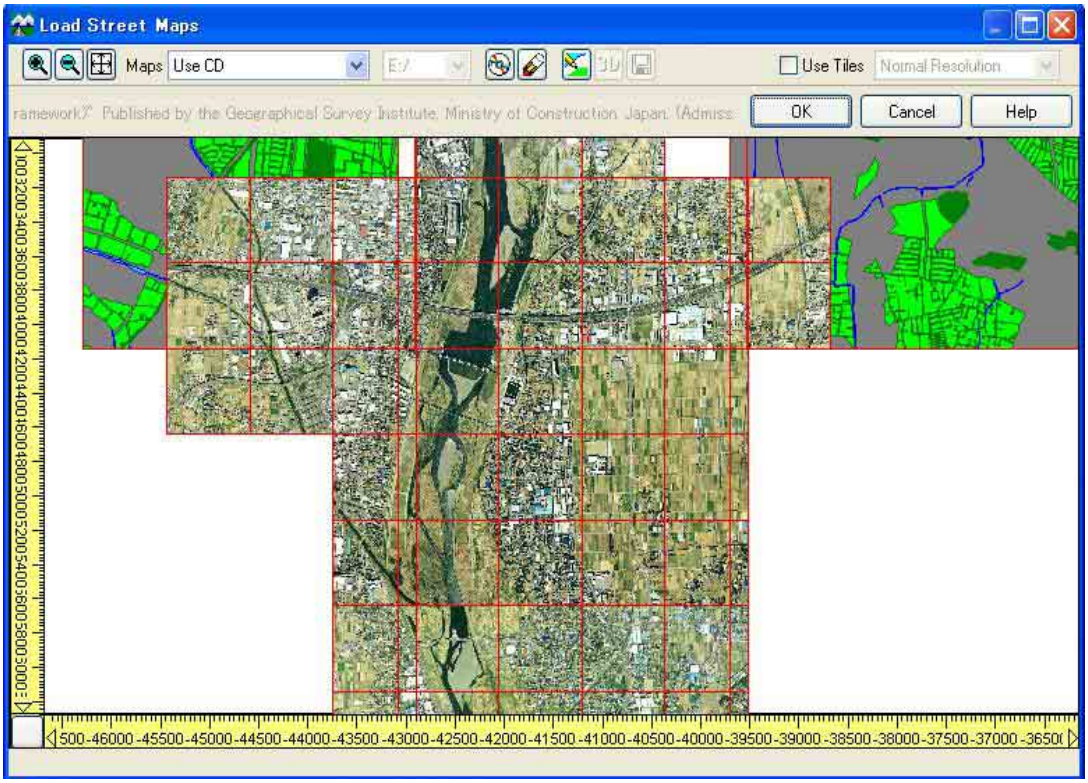

Figure 1

Finally, terrain patches can be used to refine terrain data for specific areas. Terrain patches can be edited directly, or imported using a simple XML file format.

3.2. Road Definition

Roads are defined by a series of points and curves, much like road design packages. Road sections are created and applied to the road as part of the vertical curve editing. Roads are able to be attached to each other allowing the definition of on and off ramps and the creation of complex highway interchanges.

3.3. Detail

Models in the 3DS file format can be imported into UC-win/Road where they can be refined, scaled and textured. These models along with simple cross hash trees, 3D trees and road signs can easily be placed into the scene from either the main 3D view or the 2D plan view form.

3.4. Simulation

Simple traffic simulation is provided. Vehicles are randomly generated from the ends of roads at a defined rate which follow simple traffic rules. As stated previously UC-win/Road is not a fully featured traffic simulator—our intent is only to provide as realistic as possible visual representation of the synthetic world.

4. CASE STUDIES

4.1. Tajimi Construction Office, Gifu.

The Tajimi Construction Office, of the Ministry of Land, Infrastructure and Transport, has jurisdiction over the Tokai Annular Expressway. Model data for the whole of the Tokai Annular Expressway was created as a communication tool for the reform project "MICHIBUSIN" (with the Research Design Division of the Chubu Regional Bureau) and as a residential consensus tool in the Kani-Mitake Bypass project.

The model consists of over 47km of roadway. It contains Kani data (north section) and Toki data (south section). There are 23km of main highways, 8km of the Kani-Mitake bypass, 8km for interchanges, junctions and parking areas, 4.1km of 'High-tech road north-south line' and 5km of road that intersect the Tokai Annular Expressway. The model also includes 28 bridges, including the Kisogawa Bridge, the Miyuki Over-bridge, and the Toki Kawahashi Bridge. Tunnels are also part of the created model (Figure-2).

The data has been used for a theater VR tour experience "Road-construction study tour" (Figure-3). UC-win/Road was also used to carry out a simulated helicopter flight for the construction designers. The designers later flew the same route in a real helicopter flight in order to inspect the completion of the road.

The data model continues to be used for field development projects, such as adding Michinoeki (driver rest stops with toilets, restraints and a car park) and the Toki Research Park.

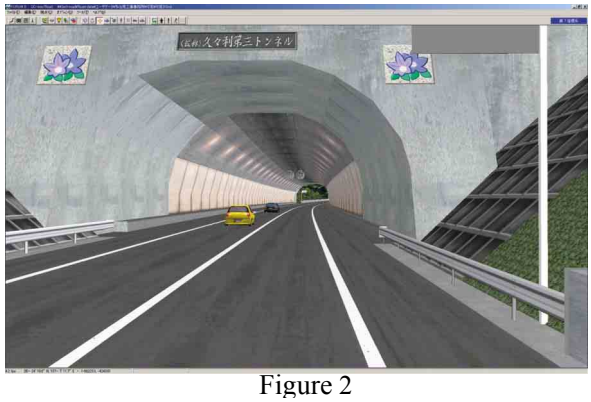

Figure 2

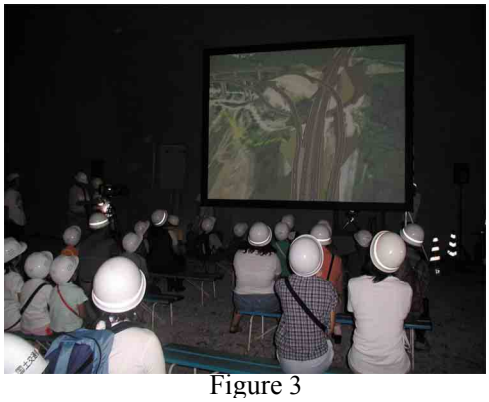

Figure 3

4.2. J-Force, Kobe.

J-FORCE (President ToshihiroYamaguchi) was formed in Oct. 2000 as a cooperative support group for consultants working in the fields of road, engineering and scenery planning. In 2001 they gave road planning technical support to the Town Development Consortium in Suma Ward Kobe City. The Town Development Consortium was organized by residents of Tenjin-cho, Suma Ward for the purpose of taking residents opinions on city road designs.

In the initial government plan, four traffic lanes were specified. After considering the landscape and the environment of the surrounding area, the consortium changed the design to two basic lanes (Figure 4). In addition they discussed building a "Historic Path" and a "Residents Center".

For residents to participate in city road design, a visual tool was required that could be easily understood and any user changes were instantly viewable. Mr. Hiroo Kasaki, a chief engineer in Aozora Foundation and Mr. Katsunori Ishida from J-FORCE participated in workshops and cooperated with residents to revise plans using UC-win/Road. This approach to planning attracted a great deal of public attention and was featured on a local TV station, SUN TV.

Figure 4

Figure 5

4.3. MAG Road Center, Toyota City.

The Tokai Belt Highway is an outer hull circular motorway in the Nagoya area which has a diameter of 40km and a length of 160km. The MAG Road Center in Toyota City, Aichi Prefecture, has had two PC's ("VR-simulating of MAG road device") running UC-win/Road with a model of a portion of the Tokai Belt Highway available for public access since July 16, 2002.

The MAG Road Center is managed by Route Meishi Office, of the Ministry of Land, Infrastructure and Transport. FORUM8 made the model data from DAI-NI TOMEI Junction to SARUNAGEYAMA tunnel. This corresponds to 21km of highway, containing three Interchanges; MATSUDAIRA, KANPACHI and FUJIOKA. There are also 13 bridges; including the KANPACHI Bridge, which has shaped arches and is a local landmark.

Any visitor can operate the VR-simulating device and experience the driving or flying simulations (Figure 6).

Figure 6

4.4. Fuji Speedway

At the Fuji International Speedway, there was a complete modification plan for the spectator stand and a management road beside the course.

Mt. Fuji being the most important landmark of the area had to visible. The usual terrain data could not be used as Mt Fuji is too large. To achieve a reasonable approximation of Mt Fuji, a large 3D model was placed 16km distant in the data (Figure 7). Scene examination was performed from every position that overlooked Mt. Fuji and a simulation of driving along the management road was carried out.

UC-win/Road was also used to model exhibition booths and displays in the open area in front of the stand at the time of an event. Using UC-win/Road it was also possible to run a simple simulation of an F1 race.

Another interesting use was to check the views of billboards from TV camera positions to assist with advertising planning and sales. Figure 8 is Camera 6, height 16m and Figure 9 is Camera 12, height 32m.

The Fuji speedway project involved many international companies in a variety of business categories, including course designers, drivers, construction engineers, TV Companies, sponsors and race officials.
UC-win/Road provided a common language to assist communications between these organizations.

Figure 7

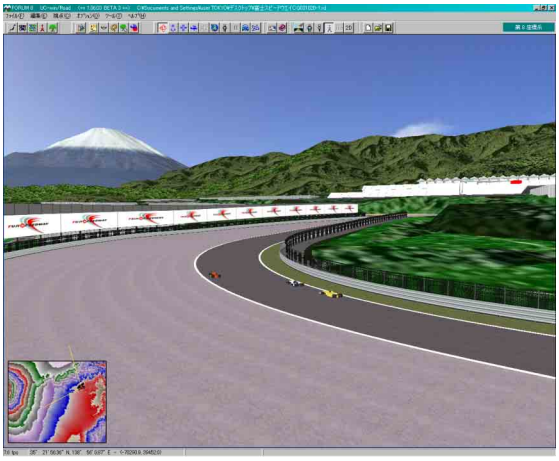

Figure 8

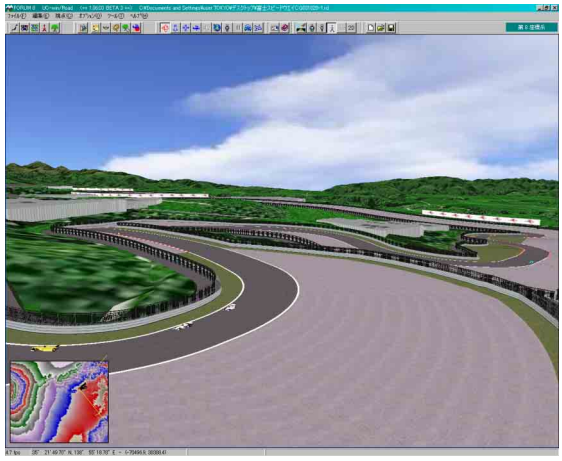

Figure 9

4.5. Railway Station Extension.

The Frontier Service Research Institute performs research and development on space usage from the viewpoint of low cost "space creation".

A VR presentation of the construction procedure for the extension of a central Tokyo railway station was created. Construction, which could normally only be performed at night due to safety considerations, can now be performed all day and night. Using the construction simulation has reduced overall costs. The construction can be performed without interrupting traffic or passengers, while trains continue running.

The construction can be checked from various viewing points; subterranean parts can be seen to check the digging state or we can view from a passenger's position within the station.

Using UC-win/Road's moving model feature (Figures 10 and 11) it was possible to create a construction procedure which could be seen from any position, to check that the movement and placement of columns and decking would not interrupt the normal running of the station.

Figure 10

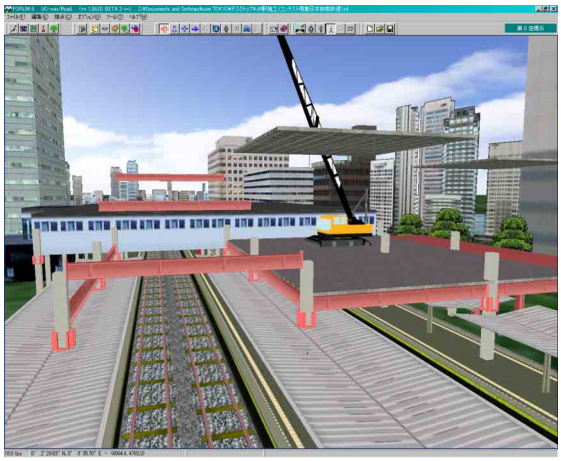

Figure 11

5. CONCLUSION

With the technological advances of 3D software and hardware in recent years, it is now possible to create a computer generated simulation of an engineering project before construction. UC-win/Road allows the developers, planners and engineers to consult with the public and visually inspect the design and its impact on the neighboring environment at minimal cost.

REFERENCES

1. *Digital Map 50m Grid (Elevation),* Geographical Survey Institute, Ministry of Construction Japan.
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