The Application Research of 3D Immersed Virtual Reality Interactive System in Landscape Architecture Design Course

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Abstract: The currently used 3D simulation technology cannot bring people a vicarious and immersive experience, and the operation of related software is inconvenient. This research has constructed a landscape virtual simulation platform, which can realize the real-time human-computer interaction and interaction between display and teaching research, by using the common software SketchUp and cooperating with the self-developed virtual visualization platform DVS3D, as well as the real-time walk-in 3D virtual reality interactive system known as G-Magic. This article describes the application of the simulation platform in an undergraduate graduation project.

Keywords: Landscape virtual simulation platform, real-time interaction, real spatial scale, 3D immersive

1 Introduction

For a long time, the teaching of landscape architecture design has been mainly dependent on oral teaching and expression of two-dimensional drawing, which lacks the support of spatial simulation and scene reappearance technologies. And with strong subjectivity but lack of the sense of reality and vicariousness during the teaching process, the teaching quality is hardly accessible to a high standard. The current 3D modelling software such as 3DMAX can partly realize 3D simulation of a site, but still lack the sense of reality.

With the rapid development of information technology, virtual simulation practice teaching has received great attention in Colleges and Universities. The main application of information technology includes multimedia technology, human-computer interaction technology, virtual reality technology, and 3D printing technology, etc. The Yale University has conducted experiments of courses such as molecular biology and cell biology with the tablet computer. The StarCAVE virtual reality system, developed by the University of California, San Diego, can display the three-dimensional virtual reality model of the Jordanian Fort in the 10th century B.C. The 3D Laboratory of the University of Victoria in Canada is equipped with the latest 3D scanner and printer, motion sensors and laser cutting machines and other high-tech equipment (WANG et al. 2015). However, the widely used VR technology requires a high level of professionalism and strong ability of computer technology application, leading to the difficulty to spread (LI & YANG 2008).

This study is one of the research projects in digital landscape laboratory of Southeast University, aiming at improving the “non-scientific” design concepts prevalent in the current landscape design. Through cooperating with a software company, we have constructed a highly realistic and feasible 3D simulation and real-time interactive virtual reality simulation platform (see: http://www.gdi.com.cn) which is more suitable for landscape architecture majors’ undergraduate graduation project. This virtual simulation platform, combining the

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teaching characteristics of landscape architecture design courses, is based on the progress of contemporary virtual simulation technologies and supported by the common software SketchUp. And by using this platform, we may discuss the use of virtual simulation technology in site scale experience and space quality improving during the teaching.

2 Material and Methodology

2.1 Software System of the Human-computer Interactive Virtual Reality Platform

In this research project, we use the regular 3D modelling software SketchUp together with the virtual visualization platform DVS3D, the walk-in 3D virtual reality interactive system G-Magic and the optical location tracking system G-Motion and other digital computer aided design tools, to develop and expand a 3D real-time display and instant interactive system, with realistic experience for the requirement of the development of the said course mainly through the common used professional software, and through which to realize a landscape virtual simulation platform with human-computer interaction (Figure 1).

1) SketchUp: Building three-dimensional model.

2) DVS3D (DESIGN & VIRTUAL REALITY & SIMULATION): This is a virtual reality collaborative platform that can access to 3D data from a variety of computer aided design software directly in real time. It can support a 1:1 immersive dimensional display of 3D models and data in a virtual reality environment and realize interactive operation in such environment only with virtual peripherals. Considering the characteristics of landscape architecture courses, our research team and the software development staff have jointly developed a “one-click to capture” function for SketchUp so that the model of SU format can be imported into DVS3D directly, which could reduce the operations steps and avoid data loss or damage during the data format conversion, and further ensure the integrity of models. (see: http://www.gdi.com.cn)

3) G-Magic Virtual Reality Interactive Display Terminal: This is an immersive virtual reality product can provide stereo images of high quality for the user with high resolution and large field of view, to let the virtual environment fully comparable to the real world. The product includes three active stereographic projectors and three high-definition screens distributed in the vision of front, side and the bottom. (See: http://www.gdi.com.cn)

4) G-Motion: This is a high precision optical location tracking system consisting of 7 infrared cameras, 3D glasses and hand-held interactive devices (remote controls), which can capture position and orientation information of objects in real time (Figure 2).

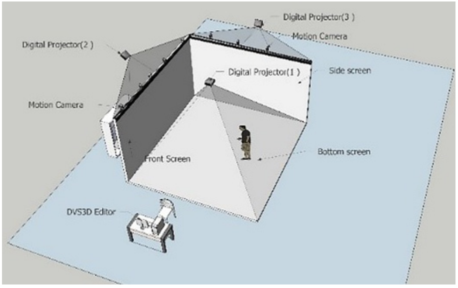


Fig. 1: Virtual Visualization Platform

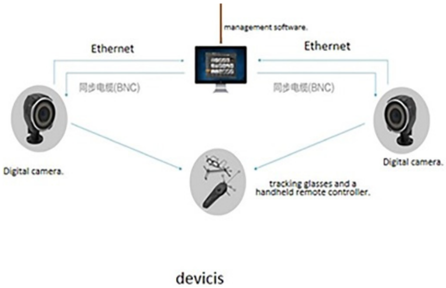


Fig. 2: G-Motion System

2.2 The Operation of the Human-computer Interactive Virtual Simulation Platform

In practical use, subjects can input their 3D design models established in SketchUp to DVS3D through the instant capture function to edit. The simulative environmental materials such as simulative model of dynamics 3D plants, people and animals, simulation of weather system can be added with the design models in DVS3D editor, which can simulate different weather conditions and the real environment with different sunshine intensity.

Then the model scene should be sent to the DVS3D client and access to the virtual reality interactive display terminal G-Magic. Projected by stereographic projectors, the scene in DVS3D client would be presented on the three high-definition screens. By adjustment of multi-channel stereo parameters, the model scene on three screens can be seamlessly presented. What's more, the scenes could be presented in 3D effect after the adjustment of visual range in stereo display parameter. Eventually, the model scene is three-dimensionally presented on three sides in the vision of front, side and bottom at a 1:1 scale.

During the presentation, the optical location tracking system G-Motion can realize real-time interaction between the scene and the subjects. The subjects need to enter into the virtual scene equipped with interactive tracking 3D glasses and the hand-held remote controllers. At this point, the simulation scene is shown around the students on three sides and the seven infrared cameras at the top of the screen can capture subjects' actions through their 3D glasses and hand-held remote controllers and send the information back to the interactive display terminal in real time. Under the cooperation of the interactive control system and the location tracking system, the image may vary its angle with the subjects' view orientation, and also shift with the subjects' location changes, thus forming a real sense of immersion in 3D effect so that subjects would have an immersive sense about their design.

The hand-held remote controller can partly modify the scene by adjusting the angle of view of the image so that viewers can grasp the overall effect of the model from a bird's-eye perspective and experience the real spatial scale from a human perspective. The remote controller can also move the scene forward and back to a large extent.

3 Application in the Teaching of Landscape Architecture Design – A Case of Undergraduate Course Graduation Project

The application of the virtual simulation platform in design can be divided into three stages: preliminary analysis, scheme design and effect display. At the stage of preliminary analysis, we can use the simulation platform to restore the site and experience it in person so as to get a stronger sense of reality, which would play a good instructive role in the early stage of the design. At the stage of scheme design, designers can get "walk-in" experience of their design, and make real-time modification of the scheme through the presentation of the design model by the simulation platform. At the stage of effect display, the simulation platform can present the expected effect of the design at a 1:1 scale. This research will take a graduation design of a graduate in Southeast University as an example to introduce the application of the virtual simulation platform in the teaching of landscape architecture design courses.

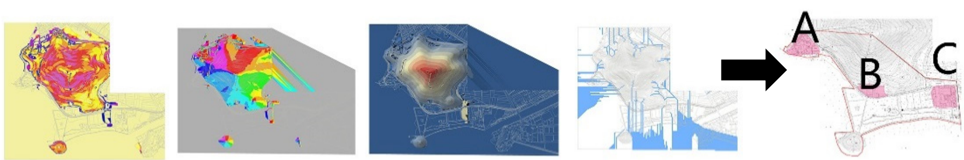
3.1 Project Profile

The graduation design is about the landscape planning and design of a resort, where is surrounded by lakes and the terrain is higher in the north with mountain field and lower in the south with plains.

3.2 Site Analysis

Road planning should adapt to the psychological and behavioural characteristics of tourists in all stratums and a variety of traffic modes should be all included such as driving, walking and water transportation etc. The selection of route and location should not destroy the natural landscape, tourists' space environment and the proper scale and proportion.

First of all, conventional GIS means were used to analyse the elevation, slope and hydrology of the site and selected the most suitable land for construction combining the evaluation of site resources (including building resources, vegetation resources and hydrologic resources) and parametric multi-factor overlay analysis. Then the virtual reality technology was applied to analyse and evaluate the site. (Figure 3)



Slope Aspect Altitude Runoff Suitable construction land

Fig. 3: GIS Analysis

The first step was to select thirty two stop points in the site (Figure 4) based on the elements of visual design in the landscape (BELL 2004) and the rules of the space build-up, and designate two roaming routes according to the site environment (Figure 5). Then the site status model was sent to the simulation platform. After that individuals of different ages and different identities were selected as subjects (Table 1) to enter into the model scene to experience the site in the designated roaming routes and stop points to get their different perceptive and evaluation of the site. The experiment has investigated the subjects' feeling about the open degree of space, spatial scale and the visibility of Taihu Lake, buildings and mountains. People of different occupations, genders and ages would have different perceptive of the field. By this investigation, we could get a more comprehensive understanding of the site. The results of the experiment are as follows.

Table 1: Information of objects

The survey selected three subjects				
Subjects	Gender	Age	Individual or In Group	Identity
A	Female	50-55	Individual	School staff without landscape architecture design background
B	Male	20-25	In group	Student of landscape architecture
C	Female	20-25	In group	Student of landscape architecture

Fig. 4: Stop points in the site

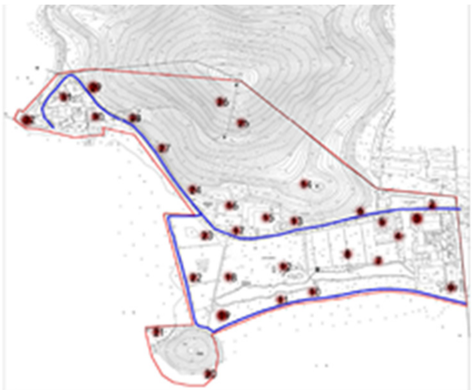


Fig. 5: Stop points and subjects in the site

Table 2: Results of the Experiment

Subject A		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
results	spatial scale	L	S	L	L	L	S	L	L	S	L	L	L	L	L	L	S
	space is open or close	O	O	C	C	O	C	O	C	O	O	C	O	O	O	O	O
	Static or dynamic	D	D	S	D	S	S	D	S	D	D	S	S	S	S	S	S
	Could see Taihu or not	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y
	Could see mount or not	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
	Could see building or not	Y	Y	N	Y	Y	N	Y	Y	Y	N	N	Y	N	Y	Y	N
	Could see road or not	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	N	Y	N	Y	Y
	Could see square or not	Y	Y	Y	N	Y	N	Y	Y	N	Y	N	Y	Y	N	Y	N

Subject A		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
results	spatial scale	L	L	L	S	L	S	S	L	S	S	S	L	L	L	L	L
	space is open or close	O	O	O	C	O	C	O	O	O	O	C	C	O	C	O	O
	Static or dynamic	D	D	S	D	D	S	S	S	D	S	D	S	S	D	D	D
	Could see Taihu or not	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Y	Y	Y
	Could see mount or not	N	N	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y
	Could see building or not	N	Y	N	Y	N	Y	N	Y	Y	N	N	Y	Y	Y	N	Y
	Could see road or not	N	N	Y	N	Y	Y	N	N	N	N	N	Y	N	N	N	N
	Could see square or not	Y	N	Y	Y	Y	N	Y	N	Y	Y	N	Y	N	Y	N	Y

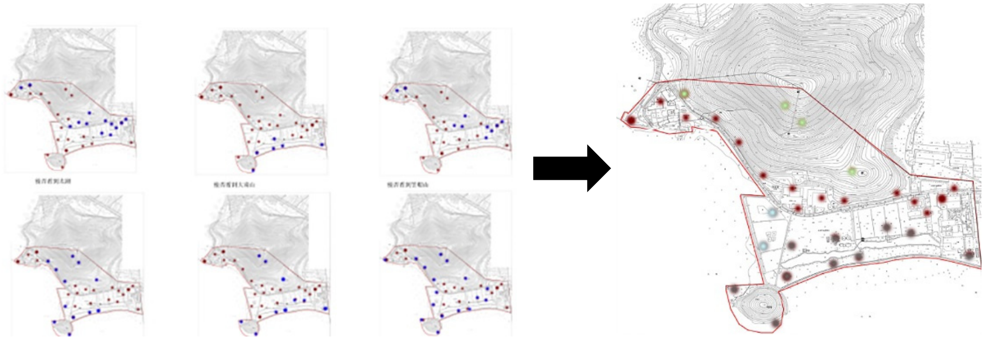
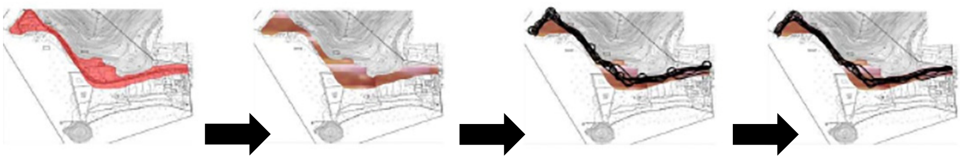


Fig. 6: Overlay Analysis Result

The next step is data analysis. The distribution of the survey factors in the field can be acquired after the data was summed up and implemented into the site plan and overlay analysed (Figure 6). Combining the GIS analysis above, the possible distribution areas of road routes, architectures and landscape nodes can be found out (Figure 7).



Select the possible selection of road site according to the GIS analysis result and design requirements.

Grid processing for selected area to carry out the possibility of the road site.

Select the appropriate node according to the scenic effect and traffic connectivity.

Generate different road tour routes.

Fig. 7: Route Selection

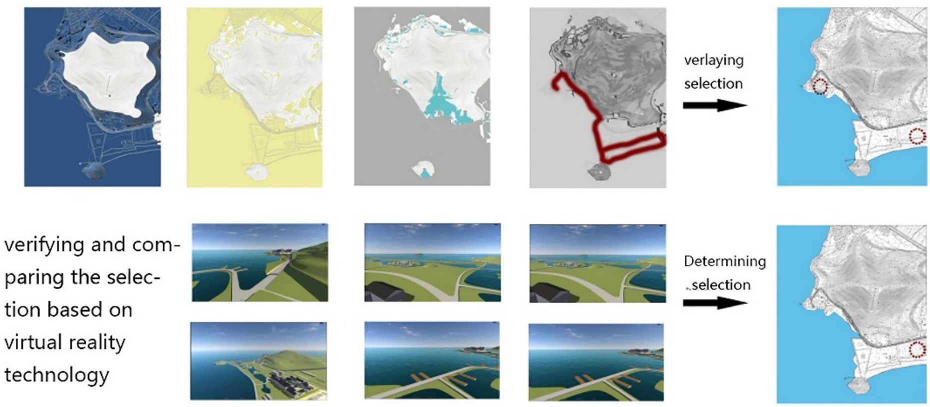


Fig. 8: The Optimal Location of Architecture Site

3.3 Scheme Design

1) Road Design: At this step, several further design schemes of road were confirmed according to the rough area of the road routes selected by the preliminary analysis and sent to virtual simulation platform. Then constantly optimized the design schemes according to experience of the subjects and got the best road design eventually.

2) Architectural Planning Stage: The architecture should be designed according to pre-selected construction location, combining the current situation of the site and design requirements. Then the sketch model was sent to simulation platform so that the designer could get the real experience about the relationship between architecture and surrounding environment and then keep optimizing the design (Figure 9).

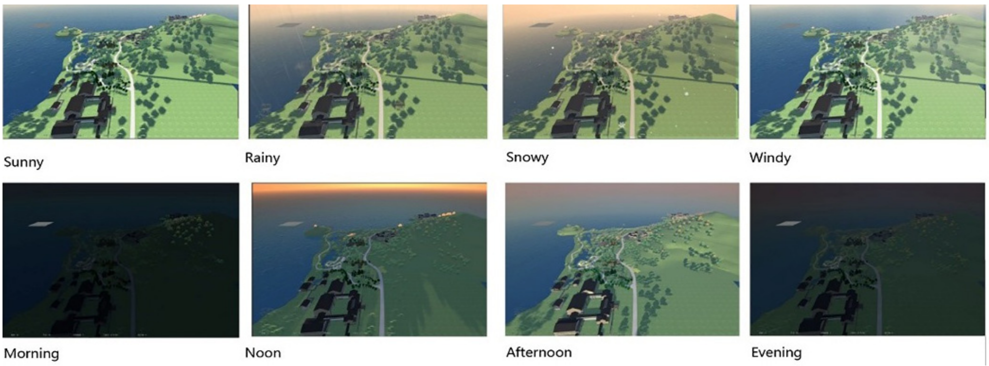


Fig. 9: Simulation of Weather System

4 Results

In the teaching process, there are basically three links being conducted alternately: teachers' teaching and reform, students' design (hand drawn and by personal computer) and three-dimensional real-time simulation in the lab. Most students can quickly grasp the simple operation of the simulation platform in merely several minutes without any professional computer knowledge. It only takes a few minutes from the model import to experience the scene, through which, the student may quickly find out their design problems and solve them, thus it enhances the students' ability of independent research. What's more, the student was motivated by the enjoyment of the immersive scene experience, which makes good teaching effect and students' satisfaction since the simulation platform has been in application.

Nowadays, landscape architecture design tends to conduct site analysis by combining the quantitative analysis based on GIS technology with subjective evaluation of the environmental quality. Before, the subjective evaluation of the environmental quality needs a large number of data of the subjective experience of the site from the users investigated, while the use of simulation platform greatly simplifies this process.

According to the application experience, the comparison among the experience in the traditional SketchUp model, in the simulation platform and in real scene is as follows:

Table 3: Comparison among SketchUp, Virtual Simulation Platform and Real Environment

	SketchUp and other traditional 3d modelling soft wares	**The human-computer interactive virtual simulation platform**	**Real environment**
Dynamic properties	Multiple perspectives, and some deviations in the spatial scale of human's viewing angle.	We can use the perspective of normal people to simulate the movement by walking, driving and other method to compare and refine the design.	The sense of reality is stronger than other methods but visual effects are limited to the human's viewing angle and changing the viewing angle and position takes a long time of the viewers.
Acoustical properties	No acoustic properties in the scenario.	Objects have real acoustic properties in the virtual reality scene.	It has real acoustic properties, and the real audio-visual experience.
Optical properties	By adding aperture to achieve, the software can reflect the real situation or design ideas in different degree.	The virtual reality system reflects the complex internal structure through the global illumination model.	It reflects the local optical properties at the real time, but it is impossible to conceive or experience the situation in different time and different seasons.
Tactile properties	None	None	Can clearly feel the wind and the real world entities.

5 Discussion

1) The virtual simulation platform is also fully applied in the display of design results of actual projects. However, there are still some limitations in the using process as follows: ① the human-computer interaction stays at the level of the scene experience because little modification can be made by the hand-held remote controller to the scene and it cannot be fed back to the design in real time. The practicability of simulation platform in landscape design will be greatly improved if the model in DVS3D client can be used to do the preliminary linkage test in Autodesk Civil3D platform, associated with CAD, Excel and other related software, to make the modification of the scene feed back to the design drawings in real time, which also lays the foundation for the quantitative control technology of engineering practice. ② Simulation platform still has flaws in the scene experience level. Firstly, the scene is limited to the size and quantity of the screens in the lab. Secondly, the experience results of scene largely depend on the fineness of model. And the material library is imperfect. Thirdly, the experience in the simulation platform lacks senses of touch and smell.

2) In combination with other relevant instruments, we can expand the application research of this project in the field of related disciplines. For example, we can combine the simulation platform with the eye tracker and galvanic skin response apparatus to study the psychological impact of the design to the observers.

6 Conclusion and Outlook

This research project constructs a three-dimensional real-time operation platform for landscape design courses according to the teaching characteristics of landscape architecture, which can create a highly realistic and exercisable virtual experiment environment for students to carry out the design course with true sense of space, vicarious experience of environment and the sense of operating the entities.

1) Good prospects: The virtual simulation platform can realize the simulative experimental environment at a 1:1 scale and combine with other devices, which plays an important role both in scientific research and teaching.

2) Strong expansion: At present, the simulation platform in the digital landscape laboratory of Southeast University has three channels (front, side, and ground). In the future, we plan to expand the simulation platform to five to six channels that can eventually achieve full immersion in scenes shown at all six directions around the subjects.

Next, this research will continue to improve the function of the virtual simulation platform, finding a better way to access the simulation platform to SketchUp without the scene transmission process, and realize the direct modification of the design model during the experience.

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