NEW METHODS FOR URBAN DESIGN AND ARCHITECTURE USING THE VR TECHNIQUE AND ANALYSIS OF THE PSYCHOLOGICAL INFLUENCE

R. SATO
Osaka Electro-Communication University,
1130-70, Kiyotaki, Shijonawate, Osaka, 575-0063
sato@dg.osakac.ac.jp

AND

W. YEO, A. KAGA
Osaka University, 2-1, Yamada-Oka, Suita, Osaka, 565-0071
{ yeo, atsuko_kaga}@env.eng.osaka-u.ac.jp

AND

M. OYAMA
Kwansei University, 1-1-155, Uegahara, Nishinomiya Hyogo JAPAN
oyama@kwansei.ac.jp

Abstract. Urban plan and architecture require the use of VR systems. We adapted the buildings into a VR system, and then performed a virtual realization in the world's largest dome at Matsushita Electric Works, Ltd. Walking or flying through life-size space was enabled. We viewed the planned future scenes that featured real size, space composition, and a simulated environment. The construction, the materials and colors of the building were examined. In addition, VR system on PC was applied to city planning and architectural design and a number of novel functions were added to the VR system by plug-in, which assisted and facilitated the design process. The stereoscopic thinking mode in 3-D space can inspire and comprehend more directly the ideas of design, and confirm the intended effects. We accordingly carried out a further study on users operating the VR system to investigate their responses of "like" or "dislike" towards the real time adjustments of design effect at identical viewpoints. Fractals analysis was conducted to demonstrate physically the influence of real time 3-dimentional design and presentation on the psychological trends of subjective judgment. Our findings pave the way for future

research on monitoring psychological impacts on observers of VR system during design process.

1. Introduction

Urban plan and architecture require the use of VR systems. We adapted the buildings into a VR system, and then performed a virtual realization in the world's largest dome at Matsushita Electric Works, Ltd. Walking or flying through life-size space was enabled. We viewed the planned future scenes that featured real size, space composition, and a simulated environment. The construction, the materials and colors of the building were examined.

The original system is not a supporting environment that can be used at any time due to its high expenses. Therefore, a system using virtual reality technique on a PC was also developed to perform expression and design of urban plan or architecture, so that designer, other users can enter the system at their will. Although the effect of a simulation is more intelligible than that of a drawing or a model, its impact on viewers, resulting from the life-size environment, may be different.

To verify the effect of a simulation using VR, our research team has applied VR system to various new thinking and the design method. Using VR system on PC in this field let us join the projects more freely. Therefore, while we took VR system into the actual project and examined the new design technique, various comparisons and analyses were performed. For example, people can use mouse to change the buildings styles or heights easily not only for checking the skyline or the position of buildings, but also checking the surrounding sound, and various persons can join the project to offer some opinions or get some new ideas because they can understand the intention of the design easily through using the system.

In order to identify the influence of 3-dimentional real time design and presentation on the psychological responses of observers, we carried out a survey by questionnaire to investigate the trends of subjective judgment when subjects view the designed objects and their surrounding environments at identical viewpoints, and demonstrated physically these trends by using fractals analysis.

The purpose of the present study is to improve design process by using the VR system and plug-in of some new techniques, as well as to employ VR system in design process for the examination of effects by detecting the trends of subjective judgement.

2. Using the VR Dome system

Regarding research of the new design technique using VR, we carried out various projects. The sample project used Architect Tadao Ando's work. In this case, a simulation was performed using the largest dome type screen of Matsushita Electric Works. In this VR Dome, there is a space that can accommodate 30 people and it is possible to advance into the building of the future using 3D glasses. A walk-through was freely carried out in the designed building. We can feel that we are in there actually and see the circumference scene of construction in detail [Figure.1].

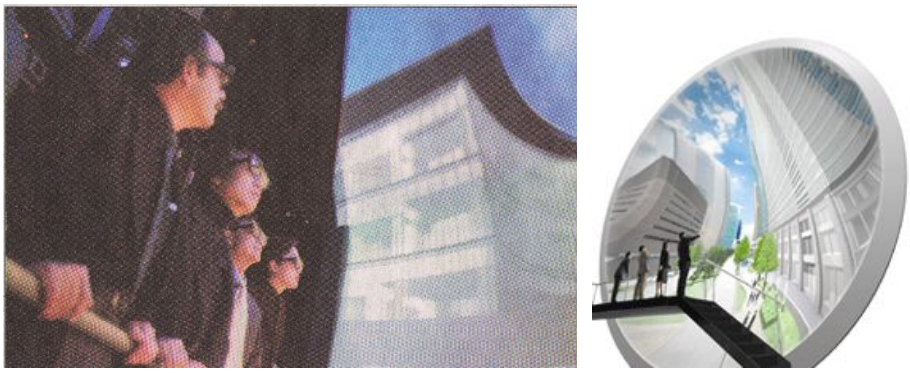

Figure 1. The world's largest dome system (Matsushita Electric Works, Ltd.)

VR dome is very useful for the check of a design. Not only checking the contents stated above in VR dome but a future maintenance and a future use plan can be used.

3. Performance of the VR system on a PC

Although various effects were achieved using life-size virtual reality with the VR Dome, detailed designs of a system of VR used on a PC are also being considered. In the design of the Qingdao project, in order to inquire into the design process, we have made some plug-in functions like changing buildings style or height by real time [Fig.2]. A surrounding sound can also be heard.

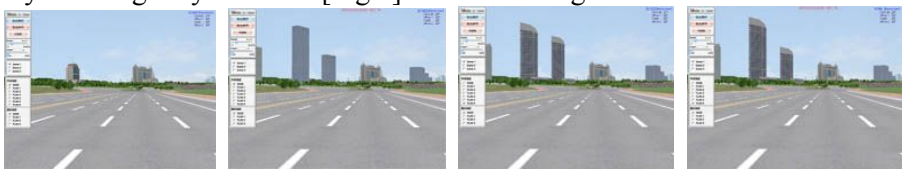

Figure 2. Changing the buildings style or height.

Thus, the features of a concrete design problem are extracted for each project, and the techniques for use of VR are devised. For example, an actual sound is taken in, and some analysis systems for checking environment or setup human-activities place, etc. Furthermore, new design techniques, such as the scenario script, plug-in method using VR, and expression of a fluid are proposed from the viewpoint of environment, action, and place. Some of our projects are introduced below.

Figure. 3: "river flow" and making mountains five times higher to understand the current status of the natural environment

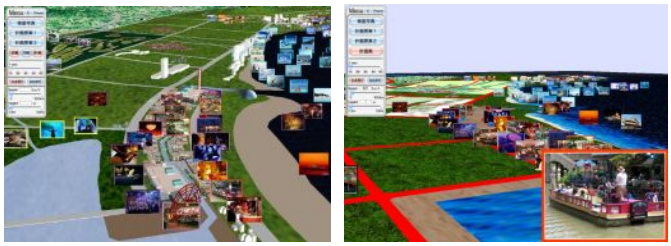

Figure. 4: The human activity in the area

4. Analysis of the VR design system user

As described in the previous sections, applications of VR to city planning and architectural design have advanced significantly. In order to demonstrate the scientific basis of these advances of applications, we investigated and analysed the responses and subjective judgments of observers who viewed VR at certain viewpoints. We hypothesize that although people have different aesthetic criteria, the majority exhibit similar trends. Identifying the principles of these trends is useful for future design process.

We used the integrated movement of VR to search for these principles. The positions of designed architectural objects were adjusted vertically at the same viewpoint. The observers were asked to respond and their reactions, from "like" to "dislike", were recorded [Fig.6]. The vertical adjustments of architectural objects resulted in changes of skyline scenes and consequently impacted the buildings surrounding the objects in design. [Fig.5]

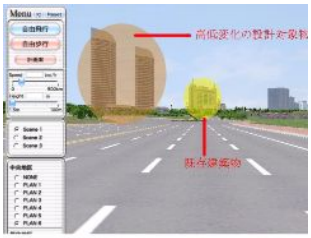

Figure 5. Adjustment of designed and existing objects

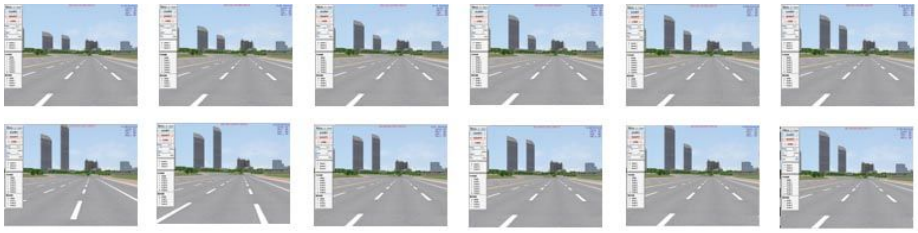

Figure 6. Different patterns and their impacts on the existing objects

We used fractals to examine the responses of observers in our study. Fractals is a calculation for quantitating the complex structures shown in many natural patterns. It has been demonstrated that the pattern of high-level cognitive activities of scientists and artists can be physically analysed using fractals which is accordingly termed "natural fingerprints " or "neo-aesthetics". Taylor et al. investigate the human responses to fractals and show that fractal images generated by mathematical, natural and human processes possess a shared aesthetic quality based on visual complexity.

In our study, 30 people were investigated. The "like" and "dislike" responses were analyzed to identify trends that were then calculated by Fractals. The principles of people's responses to fractals were revealed. Our purpose is to discover the cognitive patterns of integrated image perception and to obtain the types of emotional information from the images. The results may serve as the basis for future scientific criteria of judging design work by examining human responses to image patterns.

(1). Experimental Procedure: Observers adjusted real time the heights of two buildings in the VR system and indicated their responses to the resulting integrated images of different patterns. The responses were then classified into "like", "neutral" and "dislike".

Image for "like"

Figure 7: Group "like"

Image for “neutral”

Figure 8: Group “neutral”

Image for “dislike”

Figure 9: Group “dislike”

(2). Fractals analysis: The above images and responses were analyzed using fractals software for flat (2 dimensional) and stereo (3 dimensional) fractals calculation [Fig 10]. The results are shown in Figure 11.

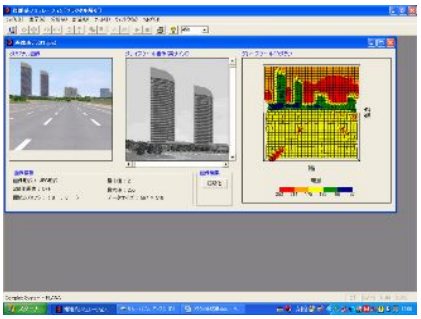

Figure 10. Analysis using fractals software

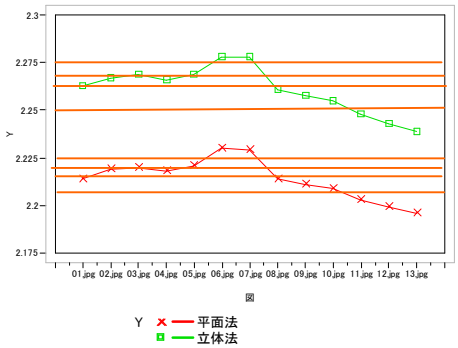

Figure 11. Fractals Calculation

Similar trends were obtained using either flat (2-dimensional) or stereo (3-dimensional) calculations. The two of the values were also similar.

(3).Comparison and Analysis: Comparison of answers to questionnaire and fractals calculations for responses of "like", "neutral" and "dislike" indicated that, in stereo calculation, Group "dislike" is distributed above 2.275 and below 2.25, Group "like" between 2.62 and 2.67, and Group "neutral" between 2.67 and 2.75.

5. Conclusions and Potential Applications

Different views and design methods are required depending on the surrounding environment, conditions, culture, or the purpose. According to the situation, we also have to develop a real-time simulation system individually. We will apply VR technology positively, and develop a new design method of real-time simulation.

By using fractals complex calculation to investigate human aesthetic judgment on architectural design, we found the trends of people's responses towards different groups of images, and demonstrated physically the principles of human cognitive activities for pattern aesthetics. Our results are useful for examining intended effects in design process. We plan to carry out further studies in a dynamic environment of changing view field and accuracy to assess the impact on human psychology in an integrated design process in which applications of VR system are incorporated.

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