Commercial Buildings Interior Interaction Design Based on Virtual Reality Technology

Tingting Lei¹,²,³, Guangtian Zou*⁴,⁵,⁶

¹ Ph.D Candidate, School of Architecture, Harbin Institute of Technology, China
² Ph.D Candidate, Architectural Planning and Design Institute, Harbin Institute of Technology, China
³ Ph.D Candidate, Heilongjiang Cold Region Architectural Science Key Laboratory, China
⁴ Professor, School of Architecture, Harbin Institute of Technology, China
⁵ Professor, Architectural Planning and Design Institute, Harbin Institute of Technology, China
⁶ Professor, Heilongjiang Cold Region Architectural Science Key Laboratory, China

Abstract
In modern, under the background of experience economy, the value of the commercial buildings' sensory experience and mind-identified are becoming obvious. And collaborative commercial formats become an important demand for consumer behavior. This thesis uses technical of virtual reality to simulation the three-dimensional dynamic scenes and entity behavior for commercial complex design. This paper attempts to collect and analyze the data by spatial selection, action path and sensory feedback to summarize the main factors of user’s behavior in commercial space. Analysis of the underlying causes and then to scheme evaluation and design optimization, in order to improve the effectiveness and prospect of interior design of commercial buildings, make it be a building with a sense of happiness that meets the user's behavioral psychology.

Keywords: virtual reality; interactive; commercial buildings; interior design

1. Introduction

Nowadays commercial buildings are becoming more intensive and developed integrally, the commercial building interior space is particularly important as well. Commercial buildings construction projects generally cost a lot, and the construction period is too much longer, there is a lot of public participation. So the requirements of design with comfort, economy and functional are much more than other building design requirements. From the user's view thinking about commercial building interior design is becoming an important direction.

* Contact Author: Guangtian Zou, Professor, Harbin Institute of Technology, Room 133, No.66, Dazhi Street (West), Nangang District, Harbin, Heilongjiang, China
Tel: (86) 13904818739
e-mail: zougt@hit.edu.cn

(The publisher will insert here: received, accepted)
The research of interactive design in the world is mainly focused on the performance of multimedia digital technology. The Daan Roosegaarde and Foxlin put their practice projects into their books 《Interactive landscapes》 and 《Interactive Architecture》, the books have great significance to the development of interactive design in architecture. Michael A.Fox pointed out the architecture interactive design is a collection of interactive design and architecture subject in the paper of 《Interactive Architecture Will Change Everything》, it is believed that the environment can be self-adaptation on the basis of the intelligent dynamics, which can reconfigure itself and respond, adapt to the physical changes automatically. At the same time virtual reality is just emerging as a technology in the era of artificial intelligence, this technology has been widely used in many fields, the application of virtual reality in architecture design is also gradually discovered (Table 1).

Table 1. Literature Research on Interactive Architecture.

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Year of publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>《Relational interactive architecture》</td>
<td>Croci, V</td>
<td>2010</td>
</tr>
<tr>
<td>《Interactive architecture for interactive social inclusion applications》</td>
<td>Prado, G. M; Zorzo, S. D; Trevelin, L. C; de Paiva Guimaraes, M; Gnecco, B. B</td>
<td>2011</td>
</tr>
<tr>
<td>《Dynamic interactive voice architecture》</td>
<td>Plan, Matthew</td>
<td>2009</td>
</tr>
<tr>
<td>《A methodology for interactive architecture》</td>
<td>Calderón, Carlos</td>
<td>2012</td>
</tr>
<tr>
<td>《An interactive control architecture for mobile robots》</td>
<td>Lin, Chia-How, et al.</td>
<td>2013</td>
</tr>
<tr>
<td>《Interactive Fashion Intimacy》</td>
<td>Roosegaarde, Daan</td>
<td>2011</td>
</tr>
</tbody>
</table>

Burdea published the book 《Virtual Reality Technology》 in 1994. In the book, they used 3I (immersion, interaction, imagination) to summarize the basic features of VR (Burdea, 1994). Germany introduced virtual reality to the industry of architectural design in 1991. In the following years, some companies in north America and Europe developed a large number of simulation systems, used to the architecture design and interior design, and achieved good results. In this paper, virtual reality is used as a technical means in the process of interior design, to support the scientific design method which related research process of interior space of commercial buildings.

Environmental behavior study is the discipline which to explore the relationship between human behavior and the surrounding environment, it is a branch of psychology and behavior science, is also an important part of environmental design theory, in addition, it is involved in sociology, anthropology and environmental engineering knowledge (Li, 1999). The common research methods of environmental behavior study include questionnaire, field observation, covert measurement, semantic analysis (SD), cognitive map and so on. In this study, we use virtual reality technology to create virtual scenes, locate and observe the users, and collect the users’ behavior data and analyze them.

The research on interior interactive design in commercial buildings is based on the theory of environmental behavior, and research for the interaction of the interior space. It is supposed to improve the interior design system of commercial buildings and enhancing the accuracy of design previews, at the same time can create more smooth and effective communication channels between designers and customers. The purpose of this study is to construct a set of interactive interior design methods for commercial buildings. The focus is on the users’ behavior, use the psychological process and feedback of behavior to guide the design. This method mainly relies on the virtual reality technology to build the commercial building models, and then use it in the early stage of the design and take the simulation experiments in the model to get the relevant data to analysis.

2. Interactive Embodiment of Interior Design of Commercial Architecture Based on Virtual Reality Technology

In the traditional design method, the interaction between human, architecture and environment is an abstract
display by two-dimensional images and language description, it can not be perceived with human activities and psychological emotions intuitively and truly. With the application of virtual reality technology in interior design, there will be interactive between the beginning of design plans and the users. It makes the designer as the initiative part, because they could be personally on the scene. To the design plans traditional performance as CAD, the designers are the passive part which are accepted observation. So the technology of virtual reality makes architecture more people-oriented.

Interactive interior design in two aspects, on the one hand it refers to the public participation in the design, on the other hand it is building a dynamic system between of users and building space based on the medium of information technology, it makes the interaction greatly enhanced (Xiang, 2016). In this paper, people interact with space based on the virtual reality, and then the behavior changes in a virtual space, after that the changes will be reflected in the real space. The core of interactive design is no longer a one-way thought expression of the architects, but a two-way of synthesis with experience and meaning between various relational variables (Fig.1).

Fig.1. The Process of Interactive Architecture Design Based on Virtual Reality Technology.

2.1. The Combination of Virtuality and Reality

Virtual reality means to use of a series of computer-based platform for external devices, such as projector, VR glasses helmets, audio, data gloves and sports capture to achieve the comprehensive perception from the simulation with the virtual environment and interactive technology platform (Zhao, 2009).

At present, the performance of virtual reality technology in China is mainly in the simulation space of building interior space, and then the users could have real sense of space layout and details of building facilities in the virtual space, such as the dimension, fenestration, daylight environments of doors and windows, and the coulors, patterns of architectural decoration. Such as the format like the virtual space make the users to be more interested and involved, and better than the performance of plane drawing in intuitive and attractive.

2.2. Interactive Participation in Real-time

Virtual reality technology allows the participants to move freely within the designated site and fix their spatial location using the wireless positioning device. And then fed back the data to the workstation platform for positioning and scene rendering. The last step is sending the data of simulation scene to the virtual reality
helmet the one which user wearing to show the scene to the user and make them form a real-time interactive participation.

2.3. Multi Sensory Perception Experience

Virtual reality technology is a kind of media composed of interactive computer simulation, to position and action perception of participants, replace or enhance more than one sensory and feedback, resulting into a perception which immersed in the simulation environment of virtual reality. Similar to the first movie on the world 《The Arrival of a Train at La Ciotat Station》, when the movie was playing some of the audience even escaped the movie sheds. They knew that they do not really get hurt, but some parts of the human’s brain seem to think the train was real and cause what we call "unconscious virtual travel". The response for those automatically subconscious fear, the audience cannot under control it consciously (J, 2015). It's similar with virtual reality, it use the visual, auditory sensory make us feel in a "true world", and much of the reaction of the users is the consciousness reaction for the "true world".

3. The Application of Virtual Reality Technology Commercial Building Interior Interactive Design Strategy

Virtual reality technology provides more possibilities for interior design of commercial buildings. The digital media form based on computer and network technology, it transforms the design plan with model into a virtual reality scene that one would have an immersed sense to response the behavior with the subconscious mind. And the effective analysis of this behavior makes it possible to design Interactive Strategies for commercial buildings based on virtual reality technology.

3.1. 3D Dynamic View of Real Size

According to behaviorist psychology, behavior is determined by the environment in which people live, and the stimuli of the environment react to the behavior of the organism. Zube et al in 1982 and Daniel, Vining in 1983 published papers which focus on the spatial cognition and human behavior through the experimental scientific method and the conclusion is “Experimental paradigm” of behavior that point, the authenticity and effectiveness of the data obtained from the observation of behavior which is better than the traditional ways of research such as filling out questionnaires (Frost, 2000). The human brain receives the external information through different sensory channels, and does not perceive the world as fragmented images, sounds, etc., but integrates different information within the same sensory channel to form the whole perception (Li, 2000). The 3D dynamic scene design strategy based on virtual reality technology is using the media equipment to create a realistic virtual environment. And then use the 3D registration and tracking technology, make the virtual image display device by accurately superimposed on the target tracking object, to complete the real feeling and interactive based on the virtual reality technology.

3.2. Dynamic and Static Combination of Substantive Behavior Simulation

Entity behavior simulation that based on virtual reality technology is the combination of certain behavior of users’ behavior in a simulated dynamic and static state, and eventually come to the form of digital image and to be assisted in the design process. Although due to individual differences and the environment variable factors can affect the effective organization of behavior, but through the study with self organization behavior of general biological characteristics and group wisdom, can find the laws of universality and organization which included by the human public behavior.
4. The Method with Application of Virtual Reality Technology in Commercial Building Interior Interaction Design

4.1. Experimental Virtual Simulation of Design Content

The scene model to be virtual constructed with 3DSMax, sketch up, Revit and other three-dimensional modeling software. To build the commercial building design scenarios for three-dimensional simulation modeling, in the process of modeling, the size of the internal space should be built in strict accordance with the actual size, proportion and structure, so as to restore the actual shape and proportion of the building space with the greatest extent. At the same time the realistic display and fluency operation of hardware equipment are both important, in order to meet the audience correct cognition, we take the methods of simplified modeling, improve the complicated details, use real photo mapping instead of meticulous models, after all it could be ensured the smooth interaction experience by the optimize displayed commercial buildings.

In the virtual modeling practice of design with commercial buildings (Fig.2), by the SMART+ virtual reality three dimensional modeling software to simulate and model a commercial building. To optimize the operation experience and improve the system running fluency, the experiment only meticulous modeled the necessary traffic spaces and style and color of the decoration, moreover, the construction details and accessory equipment are simplified and neglected to minimize the number of rendering planes and reduce system operation.

Fig.2. Virtual Reality Scenes built by Software Rendering.

4.2. Spatial Interaction Design Method

(1) The Internal Spatial Organization Based On Crowd Simulation

The basic layout mode of traditional commercial building is to use the pedestrian roads to connect a number of main stores, besides that arrange franchised shops and restaurants on both sides of the walkway to form a continuous and smooth shopping space. The shops is not only major income with the commercial rental, but also to be a space which the purchase behavior takes place. In order to maximize its business value, the layout and space division of shop unit space should follow the principle of optimization and equality of excellence. Therefore, use the appropriate software to simulate the users’ spatial choice in commercial buildings to provide an important reference for the design and planning of space organizations. The method of commercial building interactive design based on the virtual reality technology mainly rely on some 3D simulation software such as 3DVEGA PRIME and MASSMOTION etc., build the design plan into the virtual experiment scene, roaming mode according to the actual flow of people walking imitation, the sites will set the corresponding space flow routes automatically generated. The simulation technique can record the time spent in the experiment and the data of the plane route map. Through the analysis of the data of the plane route map, we can get the route choice of the users in the space, so as to carry out the spatial organization and format distribution more effectively.
(2) Design of Internal Flow of Shopping Organization Based On the Data Feedback of Simulation

The design of internal circulation of commercial building mainly depending on the design factors like accessibility, visibility, a sense of direction, to avoid the end of moving lines. Moreover, except the field investigation and questionnaire survey, the experiments were carried out with the application of virtual reality technology, and the experimenters will be measured inside the virtual experiment environment to obtain the feedback results which close to the real sense. The commercial building model that has been built to transform into 3D model of virtual reality. For example, using SMART+ software, SketchUp model can be imported directly to get virtual reality model. The experimenters can select the route in the virtual scene by wearing the 3D helmet to obtain the true proportion, size, and visual field (Fig.3). The real-time rendering is that when the view of the user changes, the scene he sees needs to be updated in a timely manner to ensure that the speed of graphic display updates must keep up with the speed of view change. Through the real-time tracking information to feedback, we can record the experiencer's route and combine the visual focus of the experience in the 3D virtual scene to analyze the rationality of the design plan.

![Fig.3. Sight Range of Commercial Channel with Straight Line and Arc Line](image)

4.3. Behavioral Interaction Design Method

After receiving and analyzing the sensory feedback of the experiencer, corresponding to this could arrange the plane and the height of the design plan. For example, we can use a series of questionnaires on the public space of commercial buildings for the experiencer’s psychological feelings of investigation which in the experience of virtual reality scene, and then to estimate if the space ratio is the most pleasant proportion. For example, public aisle width of 3 meters is the bottom line of psychological comfort, people will feel narrow if it below 3 meters, in the most general commercial buildings there will be 3-4.5 meters for the aisle. But when the aisle is set on the side of the atrium, most of the experiencers will be conducted on the side opposite from the atrium, and think that the 3-4.5 meters do not meet their psychological comfort, in this case, it is necessary to create a comfortable shopping environment psychologically by increasing the openness of walking space.

5. Conclusion

Virtual reality technology can simulate the interior space of commercial buildings and obtain intuitive users’ feedback. It opens a new way of virtual reality in interior design. With the display features of combination of virtuality and reality, interactive participation in real-time, multi sensory perception experience, the users can be closest to the design scheme with real experience to obtain the most effective behavior feedback and related analysis. This paper analyzes the strategy and method of commercial buildings interior design based on virtual reality technology, and shows the potential of virtual reality technology. We believe that there are still a lot of valuable applications in virtual reality technology to be tapped, and we will also use a variety of methods to explore further.

Compared with the traditional method of interior design of commercial buildings, experiential virtual space makes the design method of commercial buildings break through the traditional and conventional, and resonance through public participation must be one of the effective ways of design. For the interior design of commercial buildings, the method based on virtual reality through the processing of target tracking, to get the feedback of users’ behavior and virtual simulation the flow for the design method of commercial building. It
solves a series of problems, as that in the preconstruction of large commercial buildings that cannot be intuitive felt, caused that the effect of corresponding drawbacks could not be optimized and improved in time. On the other hand, this paper is mainly introduce the theoretical basis, and if it can be combined with specific cases for practical operation, it will put the theory and method more concrete to a new height.

Finally, the research of interior interactive design method of commercial buildings based on virtual reality is not only a new way of academic research, in practice, will also bring important influence on enhancing the level of interior design, optimizing the operations of commercial space, improving the interior comfort. We believe that in future, the technology in practice will iteration and development, and will give full play to the power of virtual reality technology.

Acknowledgements

The authors are appreciative of the valuable comments from editors and anonymous reviewers. Their detailed comments helped to improve the clarity and focus of this paper.

References