Perspective and Visualization of Dynamic Spaces using VR techniques

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By the perspective method, it is easy to produce many geometrical spatial forms. But through current computer media, we are able to control dynamic spaces. Under these circumstances, what type of role will traditional architectural elements play in this new era? This research investigates the different perceptions in various spaces. Afterward architectural elements are introduced and we test the effects on the perceptions of different spaces. Therefore the effectiveness of these elements is verified in different types of space.
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Introduction

Since the beginning of time human had always attempt to capture the visual frame by means of sketching and continue to search for better methods to reproduce the things we saw. In the 15th century, Brunnellischi began to use perspective drawings to present architectural spaces and urban-scale landscapes (Damisch, 1995). Perspective sketching had been systematically improving through out the 16th century. Architectural elements could be illustrated by ways of geometrically calculated perspective sketches; therefore, architects could utilize perspectives to reconstruct architectural spaces on paper. This has lead to the popularity of using perspective sketches as part of design process (Perez-Gomez, 1984). But the traditional perspective has its shortcomings. In comparison to the time consuming process of traditional perspective drawings, computer had provide the designers a fast and accurate method to construct perspective sketches, and produce more realistic effects. There were many ways to apply the principles of computer-aided design operation and expression, from multimedia animation to virtual reality (Mitchell, 1991; Liu, 1996). Comparing to the characteristics of drafting, virtual reality (VR) is to provide the designer a three-dimensional (3D) interactive experience and not just watching the movies (Walker, 1990). The difference between conventional media and VR was the fact VR's interactive functions will allow the designer to immerse himself in a 3D environment and concentrate on the important details (Campbell and Wells, 1996). In the perspective drawing process, lines and vanishing points are the key elements; they are the bases of perspective drawings. Therefore, by using the traditional perspective method it is easy to construct regular geometric forms such as rectangular spaces. However, spaces with curves and irregular lines are more difficult to grasp by the designer. It is even difficult for a professionally trained architect to produce such space in perspective format (Chun-De Lai, 1997). Although, architects have the ability to transform 2D images into physical space in their minds. But, to the ordinary people, the same transformation is quite difficult. With the assistance of computers, we are able to construct any shapes or

forms with ease; the designer can be in control of creating spaces of any shapes (Liu, 1996). Further along, by applying the interactive function of VR, the designer can grasp the general spatial perception (Campbell and Wells, 1996). Following these results, we attempt to probe into the spatial perception of more difficult and dynamic spaces (such as oval, irregular geometric forms and free forms). We also try to study the feedback of spatial perception produced by the professionals and novices with different media.

Review

Since the ancient times, the beginning of cave wall calligraphy, human race has continued to use picture forms to simulate the real and imaginary items. In the history of painting there are also constant technical breakthroughs and innovations (Gombrich, 1995), and the application of perspective drawing method was a very important breakthrough. Brunellischi was the first architect in the historical record to use method of central vanishing point perspective. Andrea Pozzo (1693) has talked about how architects have completed plans, elevations and other details in perspective format and transforming these architectural elements into a scaled perspective form in his book "Perspective in architecture and painting", and he further transforms 3 dimensional spaces into geometric drawing methods. This type of indirect 3D expression has helped architects to construct realistic architectural spaces through the application of perspectives. It has gradually developing in to a new way of design thinking by practicing the application of perspectives (Perez-Gomez, 1984). In constructing a perspective drawing, we start from a point and connecting with lines. This process is the base of perspective drawings. Therefore, the traditional perspective drawings are more likely to express geometric forms, like squares or spherical spaces, but the curved and irregular spaces are difficult to construct. When challenged with irregular forms (besides geometric spaces), even professionally trained architects have very difficult time transforming these spaces in to perspective drawings (Chun-De Lai, 1997). Comparing to the traditional perspective drawing methods, computer can provide the designers quicker and more accurate perspectives, also a more realistic reproduction effect. There are several dimensions of computer's application, from lines and points to multi-media animation and virtual reality (Mitchell, 1991). Computer can be applied during the conceptual stage and realistically reproduce the design (Sasada, 1999). Further more, by using the computers, the architects can create irregular form designs and realistically construct these free form spaces (Liu, 1996). The difference between VR and other computer media is the high degree of interactive functions, it will enable the designers to have a greater control and feel for the space. It also allows the designer to concentrate and have more control during detail design (Campbell, Wells, 1996). Through the different method of reproducing spaces other than the traditional geometric forms. Can traditional elements of constructing geometric forms play the same role in the new era? This research attempts to use VR as the main computer media in investigating the irregular spatial form's perceptions. Through VR we can reproduce many real like spaces and help to investigate how architectural elements influences different forms of spaces, and have participants from different backgrounds to help us analyze the differences between professionals and non-professional's feedback on spatial perceptions.

Methodology and Steps

This research uses VR as the main computer media to investigate the spatial perception of irregular forms in a 2-part experiment. The first part is to differentiate and identify the perception of different spatial forms. The second part introduces architectural elements to provide an effective test and verification, and for further analysis.

The Experiment of different space

The first phase we use 3D modeling software to construct space models (20M x 20M x 4M) and transfer it to VR. Space models are separated in to 3

Figure1 (top left): The plans of different rectangular shape

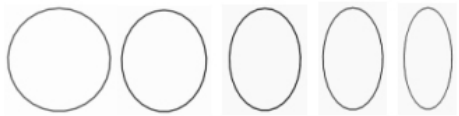

Figure 2 (top right): The plans of different circular shape

Figure 3 (bottom): The plans of different dynamic shape

groups, first group is rectangular form, second group is circular form and third group is free form. These groups are on a form changing motion (the ratio changes are: 1, 1.2, 1.4, 1.6, 1.8) to produce 4 completely different models. So there are 5 types for every group of spatial model. The first group consists of square to rectangular forms, the second group consists of spherical to oval forms, and the third group consists of free forms and its derivatives. These fifteen types are mixed and laid out to begin the experiment. There are two groups among these participants, five in each group. The first group is made up of participants with architectural professional background (graduated from architectural school, two year and above design experience) and the other group is non-architectural background (figs 1, 2 & 3).

The representation media of experiment's computer models is VR. The camera of VR is set a normal visual height of 160cm. The participants are limited to moving (X and Y axis) or rotating the camera. We initially explain the operational methods and allow questions and practice time, afterwards the participants view all the experimental models and are asked to select the comparative 2D plans (can double-check the same selection). This experiment has no limitation of time.

The Experiment of different elements

The second phase is to introduce reference elements (materials, reference lines, column lines) to the original spatial models. This process produces 45 different models (15 Models x 3 elements). After mixing the models and lay them out in order, we use the same VR method for the participants to view and ask them to select the comparative 2D plans (they can also double check). This experiment also has no limitation of time (fig 4).

Analysis and results

After analyzing the results from those two experiments, we have come up with the following diagram: X-axis is the spatial forms with different ratio, and Y-axis is the accuracy rate. The participants select the comparative plans after viewing the random models. If the selection was correct, a 1/1 value is assigned. If the selections were incorrect, then differential values are assigned (1/2, 1/4, and so on). The number of selections to acquire the accuracy rate of each plan divides the accumulations of values from the plans.

First Experiment:

In the beginning of the experiment during the process of identifying different forms, the spherical and square spaces were the most easily identified by the

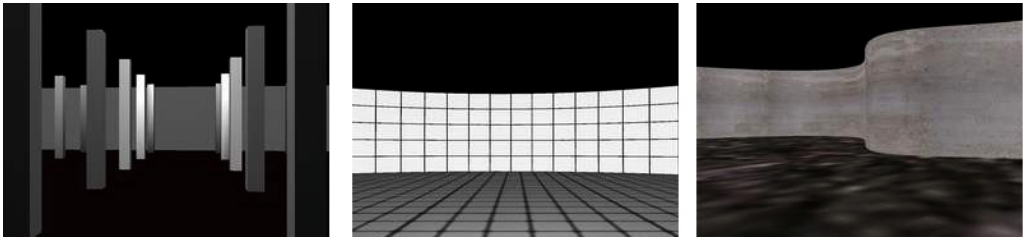

Figure 4: Three elements add to original models (columns, grid, texture)

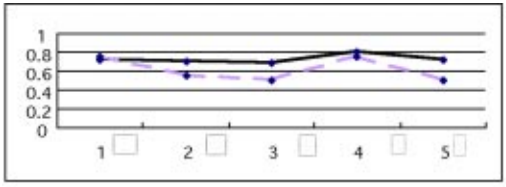

Figure 5: Perception levels of rectangular space

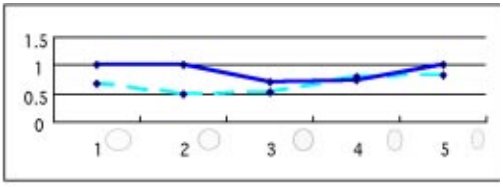

Figure 6: Perception levels of spherical space

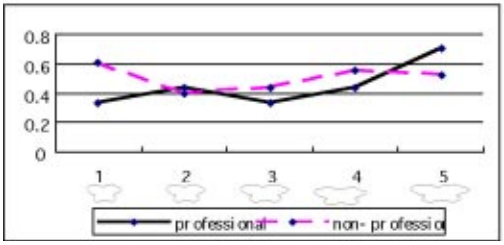

Figure 7: Perception levels of free form space

participants. As for the rectangular and oval spaces, by disregarding the level of changes, the professional have an advantage over the non-professionals. Besides all this, the participants generally have difficult time with the free form spaces (comparing to rectangular and spherical spaces). The differences between the professionals and non-professionals are relative to the changes in forms. The identification of original free forms; the non-professional's level is higher than the professionals, but when the ratio is increased to 1: 1.8, the professional exceeds the non-professional (figs 5, 6 & 7).

Second Experiment:

In the second experiment, after adding different architectural elements to the rectangular or spherical

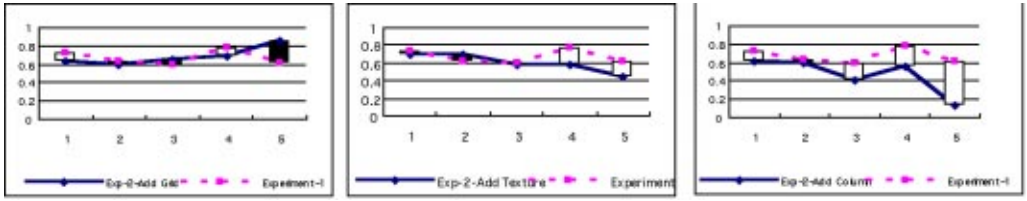

Figure 8: Perception level of rectangular space with different elements (grid, Texture, Column).

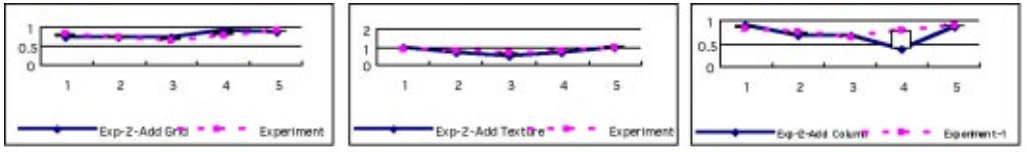

Figure 9: Perception level of spherical space with different elements (grid, Texture, Column).

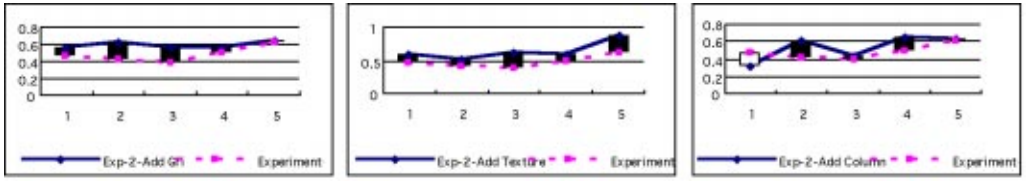

Figure 10: Perception level of free form space with different elements (grid, Texture, Column).

space, we did not get effectively improvement (comparing to the first experiment) at times it even causes to lower the perception level (for example; adding the column grids to rectangular spaces caused a decrease in perception level). But in free form space, introduction different architectural elements have clear improvement on the perception level. Therefore, by introducing architectural elements to the free forms will improve its spacial perception. The participants are able to use the added elements as a reference for identifying the spatial forms (figs 8, 9 & 10).

Conclusions and Future Studies

Before the invention of perspective we did not have systematic or scientific tools to describe what we see. After the invention of perspective method, due to its geometric characteristics, it has helped to produce many geometrical spatial forms. But through computer media, we are able to control dynamic spaces. This is very different from the traditional methods. When designing these new types of spaces, we can also use VR to produce a realistic image of the designed space, not just playing around with 2D plans and perspectives. This research investigate the different perceptions in various spaces and compare the results between professionals and amateur participants and afterward architectural elements were introduced and we test the effects on the perceptions of different spaces. Based on results from the first phase, we know the professionals have better

understanding of geometric forms. As for the free forms, all participants have difficult time identifying the correct items. But if we alter the ratio of these forms, the professionals have better chances of identify the ratio changes and make the correct choices. In the second phase, we have added 3 different architectural elements, but these elements do not necessarily have positive effect on the perceptions of the geometric forms, on the contrary, the spatial determinant elements (like column grids) have adverse effect on the accuracy of spatial perception. But these elements have positive effect on difficult perceptive items like the free form spaces, and elevated its spatial perceptions. Therefore, traditional methods of defining spaces may not be appropriate for today's application, but through the use of VR media, we are able to find the influential elements to allow the designers to use the effective elements to design different styles and types of spaces. There are some shortcomings in this research process, for example; limited participants, this may cause some inaccuracy in the experimental results. Besides this, the selection and application methods of spatial elements may also influence the results. This research used only three types of spatial elements, but in the future it is possible to consult other determinant elements in architectural spaces and conduct experiments with more spatial elements. We reserve these elements for further studies in the future.

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