VR Reality of the Relationship between Augmented Reality and Virtual Reality in the Context of Virtual Reality

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Abstract. With the development of virtual reality technology and its application in various fields, how to realize the natural and efficient interaction between human and virtual environment has always been a hot research issue. This paper mainly studies the realistic analysis of the relationship between augmented reality and virtual reality under the background of VR virtual reality. Starting from the research on virtual reality, this paper combines the features of virtual reality with the elements of visual presentation to conduct research on visual presentation in the sensory experience of virtual reality, analyze and find out the types and quantitative methods of visual presentation. This paper is supported by advance research, which is more in line with people's perceptual needs for visual presentation. This study expands the research content of virtual reality visual presentation, provides guidance for virtual reality design practitioners, and has certain value and practical application prospects.

Keywords: Virtual Reality, Visual Presentation, Sensory Experience, Human-Computer Interaction

1. Introduction

Virtual Reality (VR) is an interactive computer simulation system with multi-source information fusion. By simulating visual, tactile, auditory and other sensory information, users can interact with objects in the Virtual world in real time. Virtual reality has extremely strict requirements on the performance of computer graphics in order to achieve a high degree of realism and real-time performance [1]. In recent years, the development of computer graphics and computer hardware has made great progress in virtual reality technology. The ideal state of virtual reality is that users can interact with objects in the virtual environment in real time and get real feedback without restrictions as if they were immersive. This determines the three characteristics that virtual reality system should have: conception, immersion and interaction. Conception is the purpose of virtual reality, interactivity is the requirement of virtual reality, and immersion is the core of virtual reality [2]. In this regard, an excellent virtual reality system must first have a good sense of immersion and interaction, in order to enable users to obtain real experience, so as to achieve the purpose of conception. Interactivity is the guarantee for users to acquire a sense of immersion. Interactivity means that with the support of interactive devices, users can interact with virtual world objects generated by computers in a simple
and natural way, and a more natural and harmonious man-machine environment can be established through the bidirectional perception between users and virtual environment [3]. Therefore, human-computer interaction is the key link of virtual reality from experience to application.

In terms of the application of immersive virtual reality technology, the concept of VR technology was first proposed by the founder of VPL Exploration Company in the United States. Later, in the field related to VR technology development, the United States, as the founding country, has always been in the leading position. In terms of military and aerospace, NASA and ESA have established the VR Experimental Research Center at Johnson Space Center, and the laboratory focuses on the real-time simulation technology of the operation of the space station [4]. In the aspect of education, we have been promoting the product and concept of combining VR technology with campus education. In terms of medical treatment, Loma Linda University Medical Center for the first time used virtual reality technology for the treatment of neurological diseases in children and pioneered VR pediatric treatment [5]. In Europe, the UK is in a leading position in some aspects of VR development, especially in distributed parallel processing and traditional application research [6].

This paper provides data reference for VR experience design related practitioners in visual presentation, and focuses on the impact of visual presentation factors on virtual reality sensory experience. Taking this as a starting point, the paper puts forward a new basis for the design of virtual reality experience in the future, and gives some practical suggestions.

2. Virtual and Realistic Interaction in Virtual Reality

2.1 Basic Characteristics and Visual Presentation of Virtual Reality
(1) Basic characteristics of virtual reality

In virtual reality, the core technical performance quality is immersion, also known as the sense of presence. The so-called sense of immersion refers to the degree of reality experienced by the sensory and perceptual system when placed in the virtual environment in the state of virtual scene simulation using interactive devices [7-8]. Interactivity can be understood as the user's use of relevant virtual reality devices, people's perception of things in the virtual reality scene and the corresponding feedback from the device in the scene. Conception can also be called creativity, creativity is the beginning of virtual reality environment, virtual environment designers are based on their ideas and use creativity and imagination to build. It can be seen from the immersion, interaction and conception of virtual reality that virtual reality is not the three-dimensional simulation of the real world, but the virtual nature of natural interaction [9].

(2) Visual presentation

1) Visual reality

Visual reality refers to the reproduction of visual images in the real world with virtual reality technology. Visual reality in a virtual reality environment requires headsets and on-screen performance, and the best Oculus Rift on the market offers 2160×1200 resolution and 110° field of view. High performance devices often provide a good user experience, but the better the resolution and the better the field of view, the more realistic the user's vision.

Visual reality is also related to frame frequency. If the VR scene is too complex, there will be frame frequency lag and display delay in the VR scene, which will cause VR scene distortion.

2) Spatial vision

Spatial vision means that human beings can form a sense of spatial depth in the brain through vision, so as to judge the spatial distance between themselves and the object of concern.

Spatial vision research is divided into four kinds. The first is static depth, that is, when the user observes the static frame, the object information in the picture, such as position information, size information, relative ambiguity, etc. The second is the depth of motion. People will feel depth cues after noticing the movement of an object in a non-static image. The third is physical depth, which can be controlled by the muscles around the brain and eyes to make people feel the depth of vision. The fourth is binocular parallax, which means that the horizontal pupil distance between two eyes enables
the user to observe the object because the image information displayed horizontally in both eyes is different, resulting in the existence of parallax, which enables the user to determine the depth and position of the object [10].

The position information of the depth information of objects in the three-dimensional space of the first two kinds of virtual reality environments is obtained through the comparison and difference between objects, among which the comparison between objects can be different objects in the same virtual reality scene, or the object and the whole scene.

3) Position direction tracking

Position/direction tracking is VR's imitation of the visual rules of the real world and the dynamic response of VR images to experiencers' behaviors, which brings experiencers a sense of immersion in the behavioral system.

DikablishMD virtual reality eye tracker developed by German Ergoneers Company for many years combines eye movement tracking technology with VR technology to analyze the most authentic eye movement data of consumers in immersive experience [11]. Virtual reality eye movement apparatus is widely used in eye tracking technology is through the perception to the user when viewing objects with the eye of the eye position, to analyze the user which parts of the experiment will be pay attention to, such as the record to the user to observe the longest time of place, can analyze the user to see where the most attention. Studies related to this technology have found that the eye changes with changes in color, such as eye fixation time, pupil switching, etc. In short, any change in the design will be captured by the eye tracker when the eyeball changes, so that the design method can be adjusted through the eyeball changes [12].

2.2 Virtual Reality Environment Interaction

1) Analysis of virtual reality interaction behavior

With the development of technology, VR interaction mode is quite different from the traditional two-dimensional interaction mode. Different from the mouse and keyboard input and output on the PC end, or the click, hold, slide and other interaction methods on the mobile end, the interaction mode in the virtual reality environment is in the three-dimensional environment. What users experience is the effect of interacting with the object, rather than interacting with the object image, which is more immersive. In the virtual reality environment, touch interaction means that users interact with objects in the virtual environment through VR handles, such as touching, grasping, throwing, etc. Interfaces are actually 3D objects in a virtual environment, and users interact with them through handles.

2) Interactive feedback mode

In virtual reality applications, designing certain feedback to guide users to do interactive operations on virtual objects can improve the efficiency of users' interaction and the experience of users' interaction in the virtual environment. Feedback methods include: visual feedback, auditory feedback, tactile feedback, olfactory feedback, etc. Since olfactory feedback and auditory feedback need special equipment, the author mainly studies visual feedback and tactile feedback in the feedback experiment of this paper.

The location of visual feedback can be divided into two categories according to the needs of the situation: VR model and Vive handle. The first feedback mode appears in the 3D model of the virtual reality environment, including the interactive interface, etc. The second type of feedback appears on the Vive controller.

There are many kinds of visual feedback, and it is necessary to consider the single feedback form and the combined feedback form when designing the feedback mode in the virtual reality environment. In order to avoid the cognitive load of users caused by too many feedback styles, certain design principles should be considered in the design of feedback styles, which mainly include interference prevention, timely emergence and termination, and encouragement of users. Interference prevention means that the feedback method should avoid interfering with the user's operation. Too much feedback and style may confuse the user. Feedback should appear in a timely manner and users should not be kept waiting unnecessarily. It should disappear in a timely manner after it plays a role.
Encouraging users means that when users master basic operations or complete some system tasks, they can be given more positive feedback effects to encourage users to conduct exploratory operations.

3. Virtual Reality Interactive Feedback Experiment

3.1 Experimental Setup

This experiment will discuss the experience effect of visual feedback and force feedback. Firstly, two groups of experiments A and B were set according to the classification of force feedback, in which group A was the experiment with weak feedback and group B was the experiment with strong feedback. Secondly, each group of A and B was divided into seven groups, corresponding to seven situations in the visual feedback: highlighting graphic color, highlighting border color, highlighting background color, moving forward and zooming in the interface, highlighting the handle button, highlighting the text prompt of the handle, and highlighting the outline of the handle.

Each user is required to complete two kinds of feedback (visual feedback and force feedback) tests. In order to prevent the experimental sequence from leading to deviation of results, the sequence of feedback methods is random. For the 14 interactive tasks, each user runs a round of tests.

3.2 Task Settings

Several buttons are set in the experimental environment. When the handle touches the specified UI control, a feedback mode will appear randomly to inform the user that the virtual UI control has collided, and the user should click the next step. In order to avoid the deviation of experimental data caused by the user’s forming memory habit, the feedback method appears randomly. When the user completed an action, they were moved to the next group, where they completed the other feedback instructions again. During the experiment, in order to avoid data deviation caused by user fatigue, users will be prompted to rest for half a minute after completing each group of experimental tasks.

3.3 Experimental Optimization

Due to the noise in the sensor measurement process, the end joint shakes during the motion of the model, and the position deviation of the end joint between two frames is not stable. In general, human eyes are sensitive to low speed, especially to high speed lag, so we adopt cut-off frequency adaptive low-pass filter: by estimating the speed of the signal, the cut-off frequency of the low-pass filter is adjusted for each new sample. Although noise signals are usually sampled at a fixed frequency, filtering does not always follow the same rate, considering the actual time interval between samples, according to the following formula:

\[
\alpha = \frac{1}{1 + \frac{\tau}{T_e}}
\]  

According to the sampling period \(T_e\) and the time constant (in seconds), \(\alpha\) is calculated.

\[
\tau = \frac{1}{2\pi c}
\]  

According to formula (2), the cutoff frequency can be obtained:

\[
\hat{X}_i = (X_i + \frac{\tau}{T_e}X_{i-1}) \left\{ \frac{1}{1 + \frac{\tau}{T_e}} \right\}
\]  

\[
f_c = f_{c_{\text{min}}} + \beta |\hat{X}_i|  
\]

Then the adaptive cutoff frequency \(F_c\) can be calculated according to Equations (3) and (4). Low FCs are used at low signal speeds, and the FCs increase as the speed increases in order to reduce lag. The velocity is calculated from the original signal value using the sampling rate, and then low-pass filtering is performed using the selected cut-off frequency.
4. Experimental Results of Interactive Feedback

4.1 Average Task Completion Time

![Figure 1. Average task completion time](image)

As shown in Figure 1, the overall task completion time of the weak feedback effect was significantly higher than that of the strong feedback effect. In the visual feedback, the task completion time corresponding to the highlighted graphic color and the highlighted border color in the visual feedback of the interface is similar, while the task completion time corresponding to the highlighted background and the interface moving forward is shorter. In the visual feedback of the gamepad, the task completion time corresponding to highlighting the gamepad button is longer, which is much longer than the task completion time of text prompt and highlighting the outline of the gamepad.

It can be preliminarily inferred that the two visual feedback modes of moving the interface forward and highlighting the outline of the handle can give better prompts to users and improve the interaction efficiency of users.

4.2 Analysis of Variance

Since there are two control variables of visual feedback and force feedback in the experiment, two-factor analysis of variance is used to study whether these two control variables have significant effects on the observed variables. In the experiment, force feedback and visual feedback were taken as control variables, and interactive task completion time was taken as observation variable for a two-factor analysis of variance. The null hypothesis was: different force feedback methods had no significant effect on task completion time, while different visual feedback methods had no effect on task completion time.

| Source                        | Sum of squares | Degrees of freedom | Mean square | F      |
|-------------------------------|----------------|--------------------|-------------|--------|
| Intercept                     | 1854.362       | 1                  | 1854.362    | 20825.572 |
| Force feedback                | 174.762        | 1                  | 174.762     | 1918.457 |
| Visual feedback               | 847.209        | 5                  | 142.643     | 1593.233 |
| Force feedback * visual feedback | 93.832        | 5                  | 12.931      | 178.731  |
As shown in Table 1 and Figure 2, it can be seen that the test probability P value is significantly less than 0.05, so at least one of the force feedback, visual feedback and their interaction plays a significant role. According to the test results of influence effect corresponding to force feedback and visual feedback, the probability P value is far less than 0.05. Therefore, the null hypothesis is rejected and it is believed that force feedback and visual feedback have significant influence on task completion time respectively. According to the test of the interaction between force feedback and visual feedback, the probability value P is far less than the significance level of 0.05, it can be seen that the interaction between the two also has a significant impact on the task completion time, and the combination of force feedback and visual feedback may achieve a better effect.

5. Conclusions
This paper analyzes the research status of virtual reality interaction, classifies the interaction modes in virtual reality, analyzes and sorts out the research status of virtual reality interaction modes at home and abroad, and points out that there are few measurement studies on gamepad interaction modes in VR devices and the current situation of lack of user experience. In this paper, relevant experiments are designed, focusing on the interaction mode and interactive feedback experience of gamepads in virtual environments. Due to the limitation of research time and related conditions, this paper is difficult to cover all aspects. Future research work mainly includes the following aspects: This paper mainly studies the effects of touch interaction mode and ray interaction mode in virtual reality environment, and does not conduct in-depth research on the performance measurement and user experience of gaze interaction and gesture interaction effect. Follow-up studies can focus on analyzing and comparing the effects of other interaction modes.

References
[1] Taefi T T, Kreutz Fe Ldt J, Held T, et al. Supporting the adoption of electric vehicles in urban road freight transport – A multi-criteria analysis of policy measures in Germany. Transportation Research Part A General, 2016, 91(sep.):61-79.
[2] Castro-Nuno M, Teresa Arevalo-Quijada M. Assessing urban road safety through multidimensional indexes: Application of multicriteria decision making analysis to rank the Spanish provinces. Transport Policy, 2018, 68(SEP.):118-129.
[3] Yang C, Zhao M, Wang C, et al. Urban road DEM construction based on geometric and semantic characteristics. Earth Science Informatics, 2020, 13(1):1-14.
[4] Maltezos E, Doulamis N, Doulamis A, et al. Deep convolutional neural networks for building extraction from orthoimages and dense image matching point clouds. Journal of Applied Remote Sensing, 2017, 11(4):042620-1-042620-22.

[5] Huang S Y. A deep learning method for estimating the atmospheric pollutants removal potential of the large-scale environmental strategy based on green roofs. Air Quality Atmosphere & Health, 2021(5):1-15.

[6] Zhang F, Wu L, Zhu D, et al. Social sensing from street-level imagery: A case study in learning spatio-temporal urban mobility patterns. ISPRS journal of photogrammetry and remote sensing, 2019, 153(JUL.):48-58.

[7] Haixiang, Zou, Yang, et al. Urban Traffic State Explained by Road Networks and Spatial Variance: Approach Using Floating Car Data. Transportation Research Record, 2018, 2467(1):40-48.

[8] X Lu, Kang J, Zhu P, et al. Influence of urban road characteristics on traffic noise. Transportation Research, 2019, 75(Oct.):136-155.

[9] Fang K, X Wang, Zhang W, et al. Characteristics of space network system formed by the constituent elements in urban streets: Tianzifang in Shanghai as a case study. Journal of Asian Architecture and Building Engineering, 2020(1):1-13.

[10] Creswell A, White T, Dumoulin V, et al. Generative Adversarial Networks: An Overview. IEEE Signal Processing Magazine, 2017, 35(1):53-65.

[11] Yuan X, Tao X, Han Z, et al. SegAN: Adversarial Network with Multi-scale $L_1$ Loss for Medical Image Segmentation. Neuroinformatics, 2017, 16(6):1-10.

[12] Tang W, Tan S, Li B, et al. Automatic Steganographic Distortion Learning Using a Generative Adversarial Network. IEEE Signal Processing Letters, 2017, 24(99):1547-1551.