VR Interactive Technology and the Inheritance of Lingnan Traditional Culture in the Living Space

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Abstract: Nowadays, under the background of cultural freedom in a diverse world, the inheritance of regional culture has become a major demand of people. This article mainly researches the VR interactive technology and the inheritance of Lingnan traditional culture in the living space. First, this article briefly introduces the promotion of Lingnan traditional culture and VR interactive technology, then analyzes the characteristics and usage of VR interactive technology, and finally discusses in detail the application of Lingnan traditional culture in digital interactive design. Through the collaboration of the virtual reality software platform and related software platforms, the virtual exhibition effect of Lingnan traditional culture is displayed. While achieving the immersive and interactive exhibition effect, the efficiency of information dissemination is optimized. The experimental data indicates that: in order to improve the accuracy of placement, the error thresholds for the three directions of x, y, and z are set to 0.005 meters. If the task time is up and the user does not place the object at the target location, the task will fail, and the position of the manipulated object at the last second will be saved. The experimental results show that VR interactive technology can improve the inheritance of Lingnan traditional culture in the residential space.

1. Introduction

With the progress of society, the continuous improvement of human cultural level and the gradual progress of cultural structure level, people's demand for the cultivation of knowledge and awareness of the quality of their own culture is also increasing. At the same time, influenced by various digital technology media, the way humans perceive the world has also entered an era centered on images. Lingnan traditional culture is the glorious place of human history and civilization, but there is an embarrassment that information cannot be passed on smoothly.

With the rapid development of science and technology, the inheritance and expression methods of Lingnan traditional culture cannot fully meet the needs of the development of the digital age, and new technical forces are needed to strengthen and expand the content and tension of the heritage of Lingnan traditional culture [1]. In recent years, VR technology has been widely used in various

industries and has brought huge benefits both economically and socially. The inheritance of traditional culture also needs more new vitality in VR technology [2-3].

With the progress of society, the research on VR interactive technology has become more and more in-depth. With the help of virtual reality (VR) and computer-generated interactive environments, Freeman D's research has found that individuals can repeatedly experience their problematic situations and learn how to overcome difficulties through evidence-based psychotherapy. VR is being moved out of professional laboratories. Their main goal is to describe the potential of VR for mental health, including consideration of the first 20 years of application. A systematic review of empirical research was conducted. The main diseases he studied were anxiety (n=192), schizophrenia (n=44), substance-related diseases (n=22) and eating disorders (n=18). Although there are groundbreaking early studies, the methodological quality of the research is generally low. There is a wide gap in meaningful applications in mental health [4]. Coburn J Q's research work reviewed the latest generation of VR hardware, and focused on the past research projects that studied VR during the design process. In addition, this work proposes some new use cases that are too resource intensive to explore using previously available hardware. He found that devices such as Oculus Rift, HTC Vive, Leap Motion Controller, and Microsoft Kinect have brought immersive VR experiences into consumers' homes, with much lower cost and space requirements than previous generation VR hardware. These new devices also lower the barriers to entry for VR engineering applications. And there are great opportunities to use VR in design tasks to improve results and reduce development time [5]. Aiming at the shortcomings of the current algorithm with fixed step size, it is easy to fall into the local optimum, the robustness and transparency are poor, and the shortcomings cannot be balanced with various common attacks, and propose an optimization algorithm based on the fruit fly digital image watermarking algorithm. With the support of virtual reality technology, the original color host image is converted from RGB space to YCrCb space, and the pixel blocks of the Y component are divided into certain sizes; according to the principle of forming DC coefficients in the DCT domain, each pixel is directly calculated in the spatial domain. DC coefficients of each block, and the modification amount of each DC coefficient is determined according to the watermark information and the quantization step size. According to the distribution characteristics of DC coefficients, the watermark is directly embedded in the spatial domain. The Drosophila optimization algorithm is used to determine the type of digital watermark and the preprocessing method of digital watermark [6]. Ding Y designed and proposed an Internet-based virtual reality system for college sports based on virtual reality technology in response to the single teaching method and insufficient remote teaching ability in the current college physical education process. The system collects relevant data from the Internet of Things, interacts with virtual reality scenes in real time, renders scenes through the cloud, and experiences virtual reality through mobile terminals [7].

The main innovative work of this paper includes the following aspects: (1) At present, although there are not a few researches on traditional garden landscape design elements by relevant scholars, for analysis and ranking, there are almost no regional landscape design elements that use simple grouping and classification systems. the study. This article aims to analyze the elements of the traditional cultural landscape in the Lingnan area, and finally apply it to design practice, so that the traditional Chinese culture can be inherited. (2) The research of VR technology in environmental art design, from the point of view of computer science, puts emphasis on research, and puts the emphasis on software production and development. This article focuses on art and humanities.

2. VR Interactive Technology and Lingnan Traditional Culture

2.1 Experience Characteristics of Virtual Reality Interactive Interface

In the research of VR interactive interface, Burdi proposed the concept of "Triangle of Virtual Reality Technology" in 1993. From the perspective of technical experience, the basic characteristics of virtual reality are concisely presented. In other words, the three "I" characteristics include immersion, interactivity, and imagination. Figure 1 correctly shows the compositional relationship between virtual reality interactive interfaces [8-9].
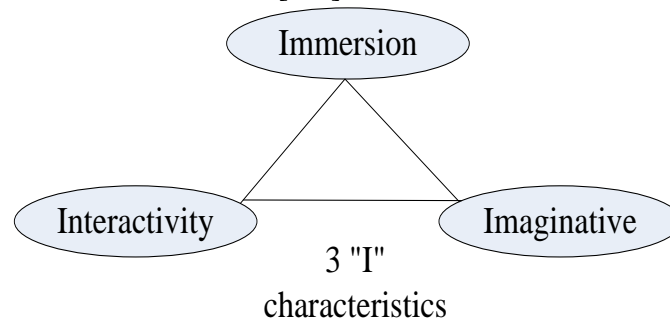
Figure 1: Virtual reality triangle configuration relationship

(1) Immersion
The virtual reality system should construct the internal environment according to the physical rules of the real world, and the system information display path should entangle the user's feelings as much as possible, and strive to truly restore the charming fantasy scene [10]. The user must immerse himself in the virtual environment created by the developer and conduct a dialogue between human and machine like a fish in a fish tank.

(2) Mutuality
The user's dialogue in the embedded environment is not a static display process, but a dynamic interactive process. Whether the user can perform more choices in the process of exchanging with the computer program is an important indicator for measuring whether the virtual reality system is fully constructed. The system needs to inform the user which action information to read and recognize [11-12]. Feedback the calculation results of the user's system program to help users make the following judgments. The interactive channel of the virtual reality system should be natural, convenient and rich.

(3) Imaginative
Imagination means that virtual reality technology helps to obtain a wider imagination, rather than being restricted by real world conditions. Virtual reality technology can use graphic-based visual elements to beautify and paint based on the actual world [13-14]. In addition, in order to reflect the designer's imagination, a series of fictional environments that do not exist in the real world can be designed completely independently. In addition, the formed dynamic change rules of various sub-objects also exceed the constraints of the actual physical laws, and the interactive effects can be freely exerted according to needs [15].

2.2 Lingnan Traditional Culture

The emergence of culture is related to a specific region. "Lingnan culture" has the general meaning of "regional culture" and is a relatively independent cultural individual formed at a specific time and space [16-17]. From a spatial perspective, the geographic area of Lingnan culture is in southern China, with five ridges facing the South China Sea. From the perspective of time, Lingnan

culture is a continuous and dynamic personal culture. The Lingnan area was the place where Baiyue and ancient people coexisted in ancient times. After the Qin and Han dynasties, many Han people from the north went south and were strongly influenced by the central culture. The modern era absorbed the essence and characteristics of various cultures such as overseas cultures [18-19]. Due to its unique historical development and natural geographical environment, as well as many factors of population mobility and the economy of the times, Guangdong Province finally formed the Guangdong folk customs that have been inherited to this day, gave birth to Lingnan culture, and formed Guangdong, Hakka and Lao people. There are three ethnic groups and seven ethnic minorities, as well as millions of unique "water dwellers", which are called "Cha ethnic group" in ancient books. Therefore, Lingnan culture has duality (multiple origins and pluralism). Characteristics. Lingnan culture has unique regional characteristics and rich connotations. As one of China's rich and diverse regional cultures, it has important cultural significance. Lingnan culture is based on the unique geographical environment of ancient Nanyue culture. In the process of development, it constantly absorbs other cultural factors of the Chinese cultural system, and while ensuring long-term exchanges and conflicts of foreign cultures, it explores a common foundation. It has a strong tolerance and openness, showing the characteristics of multiculturalism. It occupies an important position in the Chinese cultural system. In order to study the inheritance and influence of Lingnan culture, the Lingnan mentioned in this article mainly refers to the Pearl River Delta in the center of Lingnan. The historical development of Hong Kong and Macao to which Lingnan belongs is unique. In order to make the research of the paper more specific and representative, Hong Kong, Macao and Lingnan will be treated separately [20].

2.3 Artistic Characteristics of Lingnan Culture

Lingnan culture has the characteristics of practicality, openness, compatibility and innovation for the life, art and design of Lingnan area. The unique folk art of Lingnan is the common treasure of mankind.

(1) Lingnan graphics

Lingnan's traditional graphic art has a long history, rich in meaning and diverse forms. It is the result of the development of folk art and folk culture in Lingnan for thousands of years, and it is a valuable asset of Chinese traditional culture. According to the characteristics of symptoms, first can be summarized into the following categories with specific numbers. Specific graphics are good at conveying information with the reproduction of scenes, and then carving, conveying traditional beauty and rhythm through various very intuitive and vivid expressions. The second is abstract graphics [21]. Abstract graphics is a graphic language designed using the free composition of dots, lines and surfaces in traditional Chinese patterns such as moir, thunder, and Kali glass. The history of abstract graphics focuses on the performance of images. Traditional graphics based on Lingnan culture can be seen everywhere, mainly in gardens, architecture, facial makeup of Guangdong opera, plastics, folk art (wood carvings, paper-cut paintings, pottery, etc.), paintings and other art forms. The creativity of graphics is a practical activity in which people use imagination to create artistic images. Most of the previous Lingnan graphics reflect the spirit of Lingnan people praying for auspiciousness. Through people's imagination and creation, they have reached the realm of "painting is intentional and the meaning must be auspicious". These traditional graphics are the source of the inheritance and development of Lingnan culture [22-23].

(2) Lingnan color

Lingnan culture is deeply influenced by the central plane culture. With the central plane culture as the main culture, the traditional colors of Lingnan inherit the "five-color view" of the traditional Chinese colors of red, yellow, blue, white and black. Lingnan culture is an indispensable part of

Chinese traditional culture and has typical characteristics of Chinese traditional culture. "Five colors" was formed in the western part of Zhouzhou 2000 years ago, based on black and white, plus red, yellow, and blue to form the orthodox five colors [24]. Among them, the two colors of black and white embody the characteristics of dialectical thinking-"yin and yang color view". Ancient people discovered from the practice of colors that these five colors are the most basic elements of colors and the purest colors. Need to be extracted from nature, mixing them can enrich other colors. Judging from the fact that the woodblock prints in Foshan, Guangdong Province, the photos of the first month are almost colorless and overlapped, the effect of strong colors is very obvious. Folk crafts such as Cantonese embroidery, earthen sculptures, and Cantonese opera masks also use 5 colors [25-26].

(3) Lingnan modeling

The design concept of "the unity of nature and man" is one of the cores of traditional Chinese creative thinking. Since the Spring and Autumn Period and the Warring States Period, sages have valued the unity of nature and man. The philosophical thought of "the unity of nature and man" shows that the ancient creative design as the direction of value, the harmonious development of man and nature. The people of Lingnan, the representative of the elegant school, are closer to nature in artistic modeling than the rugged northerners, and can better reflect the "harmony between man and nature". Under the guidance of "the harmony between nature and mankind", Lingnan's classical plastic art emphasizes harmony and restraint, pursues the use of natural materials, and presents a simple and delicate style.

2.4 Overview of Particle Tracking Algorithm

Particle algorithm is a well-known method in computer graphics, which can be used to draw the shape, and can express irregular and complex geometric shapes such as fire, wood, and grass. In the particle method, each particle has a life cycle of "birth", "movement, growth", and "death". Through the entire particle life cycle, various dynamic properties, such as position, speed, direction of movement, life span, etc., as well as visual properties such as shape, size, color, and transparency, all change over time. In the visualization of the vector field, specific properties of the particles can be associated with the vector of the vector field. For example, in the flow field, the velocity vector can be mapped to the dynamic properties of particle motion, and other physical quantities can be mapped to other properties of the particle. Many effective generation methods have evolved from particle tracking algorithms. The trajectory of a point particle is a curve, which can be regarded as a bright point and other particles formed by the particle position x(t) at different times t. The equation of motion is

$$\frac{dx}{dt} = V(x) \tag{1}$$

Points to it, then

$$x(t + \Delta t) = x(t) + \int V(x)dt \tag{2}$$

Among them, the choice of Δt is very important. If Δt is too small, the calculation cost will increase, and if the surface is too large, the error will increase, and the particle tracking accuracy will decrease. The commonly used method now is variable time slicing. That is, the value of Δt is selected according to the speed of the vector field gradient.

3. Virtual Exhibition Experiment of Lingnan Traditional Culture

3.1 Experimental Environment and Equipment

Experimental environment: professional laboratory (need sound insulation and magnetic insulation), indoor Internet speed is good, and the desk is clean and tidy. In order to test smoothly, reduce system errors and accidental errors in data records. Experimental device: Use HTC Vive virtual reality glasses as a display device. Vive controller and HTC Tracker entity tracker as input devices. The interactive system in this article is based on the Window10 system and is developed using Unity 5.6. Experimental recording tools such as T Pro X2-30 eye tracker, camera, mobile phone, pen, and notebook.

3.2 Data Collection

There are 30 subjects in this experiment, divided into two groups, 15 people in each group. One group used HTC Vive virtual reality glasses to experience the test results. The 30 people in the experiment were all residents living in the Lingnan area. Everyone accepts the same experimental test task. Between the ages of 24 and 28, in order to ensure that all subjects have the same cognitive level, all subjects have no experience of virtual reality, and subjects have professional knowledge related to Lingnan traditional culture and crafts. The subjects' naked vision myopia is not higher than 600 degrees, and there is no color blindness.

3.3 Test Process

Usability testing is a widely accepted testing method for user extension and interaction research. This is a usability test conducted after the conceptual design model is converted into an actual website product. This can be done through user observations, questionnaire surveys, user interviews, and user tests. To achieve this goal, we must use three-dimensional functional experience, sensory experience, and emotional experience to establish usability evaluation.

(1) Preparation of resources

Before resource preparation, you need to determine the test objects, prepare test websites, testers, test tools (computers, mobile phones, another test equipment), network and other supporting test content.

(2) Design of test task

In the test task phase, we must pay attention to the task design developed based on the user's use target. The task setting must be specific and feasible, the test task sequence must conform to the user's identification and operating habits, and the amount of experiment content must be controlled to avoid user boredom and errors in experiment data. According to needs, after the test task is completed, the staff can conduct pre-test, improve the unreasonable test details, and complete the test task.

(3) Test user recruitment

Usually need to select representative users to participate. As a result, the workload and sample size of the test task can be relatively reduced, and the efficiency of investigation and analysis can be improved. According to the needs of the experiment content, recruit the number of people to take the exam. When recruiting representative users, you can start from the following 3 perspectives. 1) Residents in Lingnan area, including basic information on gender, age, etc., 2) Love Lingnan culture, and ask questions such as traditional culture listing, history learning, etc. 3) Have the skills to make traditional Lingnan handicrafts, and filter conditions such as length of study, Proficiency, etc.

(4) Test effect analysis

The 30 selected user representatives were divided into 2 groups and experienced the traditional culture of Lingnan in different ways. The user experience table was written according to the user experience, and the tester recorded according to the data in the table.

4. Application Analysis of VR Interactive Technology in Lingnan Traditional Culture

4.1 Analysis of Test Results

According to the evaluation items of the immersion questionnaire, the average value of each question is divided and processed, and the histogram shown in Figure 2 is drawn. The percentage of evaluation items of the immersion questionnaire is shown in Figure 3.
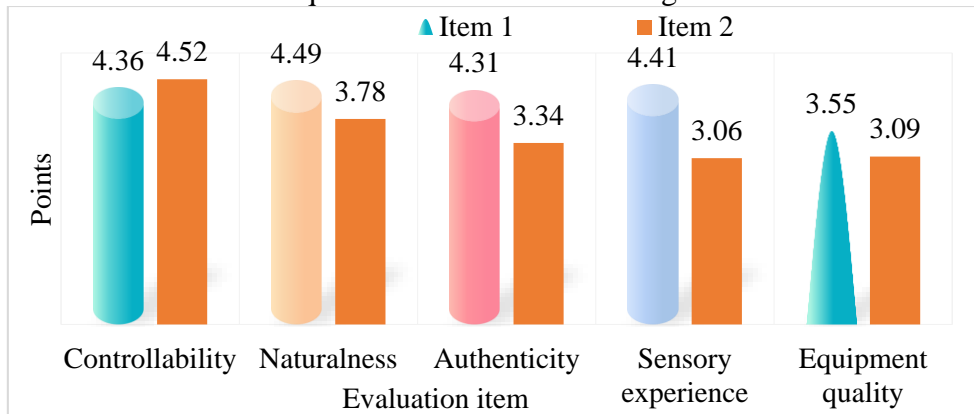

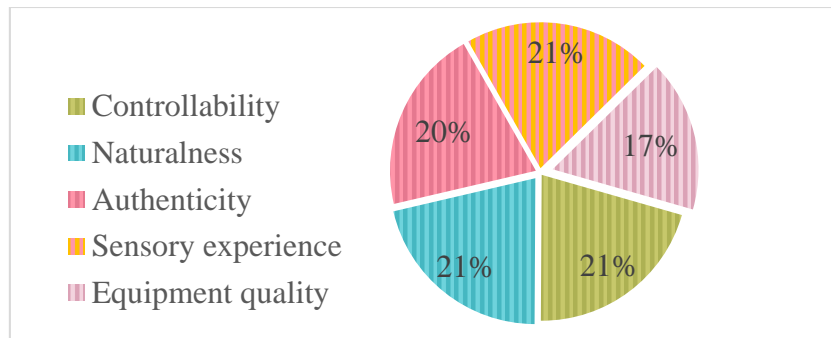Figure 2. Mean value of evaluation items of immersion questionnaire

Figure 3: Percentage of evaluation items in the immersion questionnaire

It can be seen from Figures 2 and 3 that the scores of maneuverability and naturalness in the five evaluation items are relatively high, followed by authenticity and sensory experience, and equipment quality. This shows that the participants have relatively strong controllability of the PC-based Web3D virtual reality system and interactive manipulation behavior with the virtual environment in the test task, while the immersive VR system brings the participants a sense of reality and sensory experience At a medium level, because the quality of equipment will affect the scores of other evaluation items. The VR experience part of the Lingnan traditional cultural network platform is mainly controlled by keyboard and mouse. The immersive network platform constructed by 360-degree panoramic technology and Web3D technology displays real digital images. Therefore, it will give the subject an immersive sense of reality, which directly leads to the subject's strong naturalness and authenticity in the experience. And in the auditory processing of the network platform, the soundtracks of Chinese classical stringed instruments, plucked instruments, and

percussion instruments are used to match different virtual scenes, and the response music is switched according to the scene, and the sense of space and far-sightedness produced by the auditory sense It is also the reason to strengthen the participant's immersion experience.

In general, the page immersion of the Lingnan traditional culture network platform and the immersion of the VR display system are relatively strong. In the follow-up research and iterative design, we need to pay attention to the following points: 1. It can guide users who are new to virtual display for the first time, guide users to use the network platform, understand the VR display module, and give feedback from mobile users, and patiently answer the novice users. Second, according to the user's acoustic feedback in the test task, some users feel that they will feel dizzy due to the rapid response of the operation in the virtual exhibition hall. Therefore, the virtual roaming function needs to be further optimized and technically processed in the follow-up design; Third, the travel guide problem in the virtual exhibition hall, the existing exhibition hall map is not clear, which will cause users to get lost in the virtual exhibition hall. In the subsequent design, a virtual exhibition hall map with clear guidance should be adopted, which can appropriately increase visual and auditory guidance instructions.
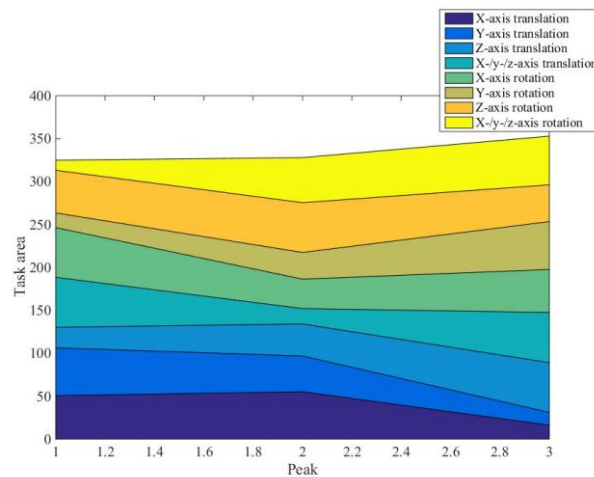
4.2 Task Setting Analysis

Figure 4: Task test area comparison chart

Table 1: Task description

	Task	Description
1	X-axis translation	Translate the object in the x-axis direction to match the target position
2	Y-axis translation	Translate the object in the y-axis direction to match the target position
3	Z-axis translation	Translate the object in the z-axis direction to match the target position
4	X-/y-/z-axis translation	Translate the object in the xyz axis direction to match the target position
5	X-axis rotation	Rotate the object around the x axis to match the target position
6	Y-axis rotation	Rotate the object around the y axis to match the target position
7	Z-axis rotation	Rotate the object around the z axis to match the target position
8	X-/y-/z-axis rotation	Rotate the object around the xyz axis to match the target position

A total of 10 placement tasks were set up in the test experiment, and the object was manipulated according to the target position through translation and rotation. The target position was given by a wireframe model with the same shape as the manipulated object. These 10 tasks are timed tasks. In order to prevent users from getting too tired, each task has a maximum time limit of 60 seconds.

There are three ways to enter the next task. The user successfully matches the object with the target position and automatically enters the next task. The task time is up to automatically enter the next task, and the user chooses to abandon the current task. An error threshold is set for the placement task. When the user places an object within the error threshold of the target position, the color of the object will change to green, indicating that the task is successful and enter the next task. In order to improve the accuracy of placement, the error thresholds for the x, y, and z directions are set to 0.005 meters. If the task time is up and the user does not place the object at the target location, the task will fail, and the position of the manipulated object at the last second will be saved. Table 1 shows the description of each task. The task test area comparison chart is shown in Figure 4.

4.3 Fuzzy Comprehensive Evaluation Results

The fuzzy evaluation of gesture recognition of the VR system is constructed according to the evaluation matrix of the first two sections, and ten actions of gesture recognition can be obtained, as shown in Table 2. It can be seen that the scores for the fuzzy evaluation of the ten-gesture recognition recognition are basically consistent with the scoring trend of the user subjective emotion test. The actions with better recognition are A1, A2, A7 and A8, and the actions with poor recognition are A9 and A8. A10 action. The fuzzy evaluation model can better reflect the recognition degree of the gesture recognition of the VR system. The comparison of performance measurement fuzzy score and subjective test score is shown in Figure 5.

Table 2: Fuzzy evaluation of gesture recognition

| Action	Gesture instructions	Fuzzy evaluation
A1	One-handed continuous forward (right-hand operation)	Excellent recognition
A2	One-handed continuous backwards (right-hand operation)	Recognition
A3	Continue to the left with one hand (right-hand operation)	Excellent recognition
A4	One-handed to the right (right-hand operation)	Good recognition
A5	One-handed continuous forward (left-hand operation)	Good recognition
A6	One-handed continuous backwards (left-hand operation)	Good recognition
A7	Continue to the left with one hand (left-hand operation)	Excellent recognition
A8	One-handed to the right (left-hand operation)	Excellent recognition
A9	Left hand in front and right hand in back (two-handed operation)	Poor recognition
A10	Right hand in front and left hand in back (two-handed operation)	Poor recognition
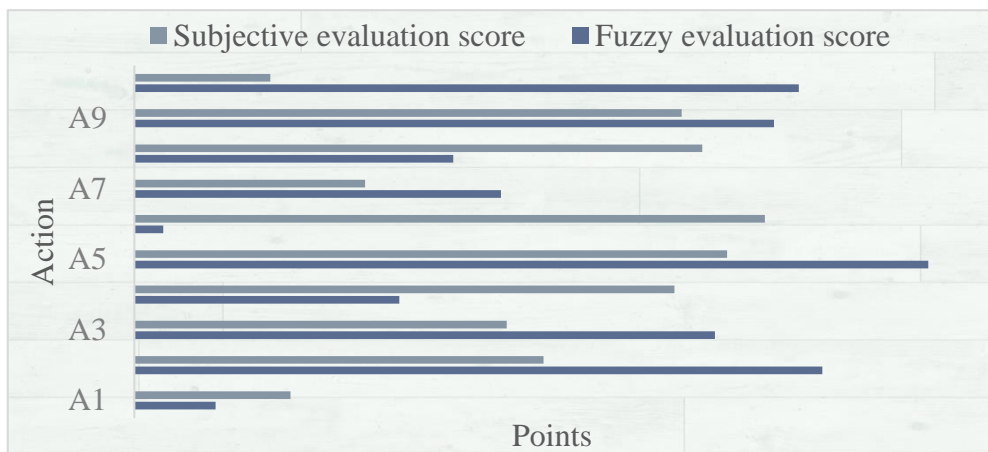
Figure 5: Comparison of performance measurement fuzzy score and subjective test score

The fuzzy evaluation of arm fatigue is divided into "severe fatigue", "slight fatigue", "relaxed", and "very easy". According to the weights of 4.5, 4, 3.5, and 3, the fuzzy evaluation of overall fatigue can be obtained and subjective evaluation to another score distribution. Comprehensive data of left-hand and right-hand fatigue and subjective data are compared and analyzed. It can be seen that the fuzzy evaluation scores of these 17 gesture points are basically consistent with the user subjective emotional test score trend. This fuzzy evaluation model can better reflect the VR system. Fatigue of gesture interaction.

This experiment uses quantitative data as the blueprint, establishes a fuzzy set, establishes a membership function, determines the corresponding membership relationship, calculates the index weight, and obtains the membership evaluation matrix. Through the subjective and objective verification, a fuzzy comprehensive evaluation model is established. It also analyzes and verifies the results of performance measurement and fatigue experiments. The fuzzy evaluation results of gesture recognition performance measurement and gesture interaction fatigue are basically consistent with the subjective test evaluation. The final verification results can clearly indicate the evaluation system proposed in this paper. The quantification method and the constructed fuzzy evaluation model can be applied to evaluate the gesture interaction evaluation system of the VR system.

5. Conclusions

This paper proposes a new vector field interactive visualization method based on the VR environment. It mainly studies the key technology of vector field data interactive visualization based on the virtual reality environment, and organically combines the interactive technology of virtual reality and the visualization of vector field data. Users can naturally interact with vector field data through peripheral devices such as tracking devices, three-dimensional mice, and data gloves to discover interesting or hidden details in the data more quickly, and change many abstract and incomprehensible principles and laws. At the beginning, in order to facilitate understanding, the report recorded the realization principle of this method and studied several main technologies. VR-based interactive visualization of vector field data first visualizes vector field data. In other words, it accepts input of vector field data in a specific form, performs various visualization processing, and finally outputs the visualization result. However, unlike the general visualization based on the virtual reality environment, with the help of the interactive technology of virtual reality, the user can naturally operate the visualization scene of the vector field data.

Study the application of multi-touch interaction technology in the process of scientific visualization interaction, solve the core challenges from two-dimensional input to three-dimensional operation, and design more natural and advanced interaction methods. Including multi-point gesture design, gesture recognition, etc. The 7-degree-of-freedom interaction with the structured three-dimensional model is achieved through 3-degree-of-freedom translation, 3-degree-of-freedom rotation, and 1-degree-of-freedom overall zooming touch interaction. At the same time, a new interactive method that rotates around the point specified by the user is proposed. By providing in-depth information and unlimited partition interaction, the user's spatial recognition is improved.

Through the research on the VR input method and the handle-based interactive means, the interaction elements that need to be paid attention to in the handle-based industrial design viewpoint are summarized: button function design, button coding design, handle shape design, etc. However, different from the user's perspective, the factors that affect steering wheel operation are summarized from two aspects: key figures and user gestures. In the research based on the supplementary input method, the component comparison between the technologies was comprehensively discussed. In the research based on the virtual interaction method, the five basic forms of human-computer

interaction, normal camera interaction, touch interaction, sensor interaction, and shortcut key interaction summarize interaction.

References

[1] Donghui C, Guanfa L, Wensheng Z, et al. Virtual reality technology applied in digitalization of cultural heritage[J]. Cluster Computing, 2017, 22(4):1-12.

[2] Sajitha V R, Nijas C M, Roshna T K, et al. Compact cross loop resonator based chipless RFID tag with polarization insensitivity[J]. Microwave and Optical Technology Letters, 2016, 58(4):944-947.

[3] Oyewunmi O A, Taleb A I, Haslam A J, et al. On the use of SAFT-VR Mie for assessing large-glide fluorocarbon working-fluid mixtures in organic Rankine cycles[J]. Applied Energy, 2016, 163(Feb.1):263-282.

[4] Freeman D, Reeve S, Robinson A, et al. Virtual reality in the assessment, understanding, and treatment of mental health disorders[J]. Psychological Medicine, 2017, 47(14):1-8.

[5] Coburn J Q, Freeman I J, Salmon J L. A Review of the Capabilities of Current Low-Cost Virtual Reality Technology and Its Potential to Enhance the Design Process[J]. Journal of Computing & Information ence in Engineering, 2017, 17(3):031013.1-031013.15.

[6] Zhang Y, Ma X L. Research on image digital watermarking optimization algorithm under virtual reality technology[J]. Discrete & Continuous Dynamical Systems, 2019, 12(4&5):1427-1440.

[7] Ding Y, Li Y, Cheng L. Application of Internet of Things and virtual reality technology in college physical education[J]. IEEE Access, 2020, PP(99):1-1

[8] Bartolini I, Moscato V, Pensa R G, et al. Recommending multimedia visiting paths in cultural heritage applications[J]. Multimedia Tools and Applications, 2016, 75(7):3813-3842.

[9] Guzman P C, Roders A R P, Colenbrander B J F. Measuring links between cultural heritage management and sustainable urban development: An overview of global monitoring tools[J]. Cities, 2017, 60(PT.A):192-201.

[10] Nakamura S, Fukuda M, Issaka R N, et al. An integrated approach to assess air pollution threats to cultural heritage in a semi-confined environment: The case study of Michelozzo's Courtyard in Florence (Italy)[J]. Nutrient Cycling in Agroecosystems, 2016, 106(1):47-59.

[11] Merwe, Der C D V. Tourist guides' perceptions of cultural heritage tourism in South Africa[J]. Bulletin of Geography Socio Economic, 2016, 34(34):117-130.

[12] Vojinovic Z, Hammond M, Golub D, et al. Holistic approach to flood risk assessment in areas with cultural heritage: a practical application in Ayutthaya, Thailand[J]. Natural Hazards, 2016, 81(1):1-28.

[13] Jeon M M, Kang M, Desmarais E. Residents' Perceived Quality Of Life in a Cultural-Heritage Tourism Destination[J]. Applied Research in Quality of Life, 2016, 11(1):105-123.

[14] Hong M, Jung J J, Piccialli F, et al. Social recommendation service for cultural heritage[J]. Personal & Ubiquitous Computing, 2017, 21(2):191-201.

[15] Makantasis K, Doulamis A, Doulamis N, et al. In the wild image retrieval and clustering for 3D cultural heritage landmarks reconstruction[J]. Multimedia Tools & Applications, 2016, 75(7):3593-3629.

[16] Agapiou A, Lysandrou V, Themistocleous K, et al. Risk assessment of cultural heritage sites clusters using satellite imagery and GIS: the case study of Paphos District, Cyprus[J]. Natural Hazards, 2016, 83(1 Supplement):1-16.

[17] Cappelletto E, Zanuttigh P, Cortelazzo G M. 3D scanning of cultural heritage with consumer depth cameras[J]. Multimedia Tools & Applications, 2016, 75(7):3631-3654.

[18] Pintus R, Pal K, Yang Y, et al. A Survey of Geometric Analysis in Cultural Heritage[J]. Computer Graphics Forum, 2016, 35(1):4-31.

[19] Sfikas K, Pratikakis I, Koutsoudis A, et al. Partial matching of 3D cultural heritage objects using panoramic views[J]. Multimedia Tools and Applications, 2016, 75(7):3693-3707.

[20] Bekele M K, Pierdicca R, Frontoni E, et al. A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage[J]. Journal on Computing and Cultural Heritage, 2018, 11(2):1-36.

[21] Micheluz A, Sulyok M, Manente S, et al. Fungal secondary metabolite analysis applied to Cultural Heritage: the case of a contaminated library in Venice[J]. World Mycotoxin Journal, 2016, 9(3):1-12.

[22] Korzun D, Varfolomeyev A, Yalovitsyna S, et al. Semantic infrastructure of a smart museum: toward making cultural heritage knowledge usable and creatable by visitors and professionals[J]. Personal and Ubiquitous Computing, 2017, 21(2):345-354.

[23] Torruella A. NAWCTSD receives VR prototype for mission rehearsal[J]. Janes International Defense Review, 2017, 50(FEB.):8-8.

[24] Sang Y, Zhu Y, Zhao H, et al. Study on an Interactive Truck Crane Simulation Platform Based on Virtual Reality Technology[J]. International Journal of Distance Education Technologies, 2016, 14(2):64-78.

[25] Panadero E, Brown G T L, Strijbos J W. The Future of Student Self-Assessment: a Review of Known Unknowns

and Potential Directions[J]. Educational Psychology Review, 2016, 28(4):1-28.

[26] Maples-Keller J L, Bunnell B E, Kim S J, et al. The Use of Virtual Reality Technology in the Treatment of Anxiety and Other Psychiatric Disorders[J]. Harvard Review of Psychiatry, 2017, 25(3):103-113.