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Digital Art Design and Media Practice Integrating CAD and Virtual Reality Technology

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Abstract. Digital media art, as an emerging form of media and mass art, has greatly surpassed traditional art forms such as painting, dance, and film due to its comprehensive technical means and cross media characteristics. In recent years, the development of computer information technology, especially the enhancement of graphic and image expressive power and the increasingly rich processing methods, has provided a wide range of expressive space for digital media art creation. The combination of graphic art computer-aided design (CAD) and multimedia technology represented by virtual reality (VR) provides the possibility for humans to achieve truly immersive art forms. This article will focus on the digital media art design and innovation under virtual reality technology. The biggest feature of VR works is not only to provide the audience with an experience of participating and interacting with "real" works, but also to rely on technical means to emphasize the gender and emotions of artistic works, thereby enhancing the audience's attractiveness to the target. This system compensates for the shortcomings of traditional presentation modes by overlaying virtual digital information such as the Great Wall 3D model and audio and video in real scenes, and adding interactive functions. While increasing interest, it can better spread the splendid culture of Chinese history, make cultural relics speak better, and tell people the wisdom of history.

Keywords: Computer-Aided; Art and Design; Digital and Virtual Reality; Human-Computer Interaction
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1 INTRODUCTION

Due to the rapid development of semiconductor, computer, and communication technologies, digital information technology based on microelectronics has developed rapidly, and multimedia technology has been rapidly developed and widely applied. People are liberated from monotonous data input and enter a rich and colorful graphical world. However, currently this two-dimensional graphical interface has serious limitations and is fundamentally different from human natural perception habits, so it is still referred to as a computer-centric interface technology. One of the most prominent features of CAD virtual reality art is its immersive nature, which refers to the sensory channels provided by specific environments and the breadth and depth of sensory information obtained by people. From the perspective of informatics, humans mainly receive external information through visual and auditory means. In traditional art forms, movies and television were the best means of providing multidimensional sensory information in the past, but they can only provide visual and auditory sensory information.

CAD virtual reality technology endows art with immersion and interactivity, thus achieving "immersive art". In the virtual world constructed by digital media art, it is difficult to distinguish between what is real and what is not. The reality created through digital virtuality is even more real than real existence. Virtual space scene digitization technology can not only use computers to create digital creatures as movie protagonists, but also create virtual space scenes that are difficult to shoot in real life, expanding the expressive space. Abugharbieh and Marar [1] enhanced the performance of mixed signals in digital circuits using computer-aided tools. The design layout of the designed static storage array was simulated. Virtual space scenes can be simulations of real or imagined virtual worlds, without being constrained by real conditions. In the history of image production, for the first time, people did not rely on light to create images (video recorders, cameras, and cameras all rely on the interaction between real light and photosensitive film), but instead used numbers to create images. The virtuality of digital media art has given new meaning to the concept of "reality". CAD virtual reality digital art design is the process of combining computer-aided design software with virtual reality technology to achieve digital art design. Burghardt et al. [2] used computer-aided design software for 3D modeling and other work. Then, virtual reality technology is used to present the designed virtual model in a virtual space for observation, communication, and evaluation by other personnel. It is necessary for robots to reproduce human actions that perform complex processes from a robotic perspective.

The main content of this article is to organically combine the design of target tracking technology with multi touch technology. By analyzing the characteristics of moving targets through CAD, a new interaction mode has been formed. On this basis, improvements have been made to the existing two interaction systems and a new interaction system has been proposed. Its innovation lies in:

(1) This article proposes a high-precision 3D scene generation algorithm for CAD to solve the problem of AR not being able to achieve high-precision perception of large areas in the scene in advance.

(2) This article proposes a new interaction method based on pathfinding algorithm to solve the problems of small AR perspective and difficulty in manipulating object displacement in large scenes using traditional interaction methods. When using an AR device to switch the perspective to another perspective, the objects in the previous perspective will disappear, making it difficult to operate in the current perspective.

2 RELATED WORK

CAD virtual reality technology is the construction of realistic models in computers. Cabero et al. et al. [3] investigated the motivation of augmented reality teaching materials. A positive evaluation was conducted on the motivation for participating in the experiment and the improvement of academic performance. Campbell and Evolvi [4] analyzed the emerging teaching survey of digital technology culture. Through the research on the digital spiritual religion of the network society structure, it shows the digital concept under different cultures and carries forward the online and offline religious space. The evidence suggests that the use of augmented reality is beneficial for the learning process. Fan et al. [5] described language learning in augmented reality (AR).

With the continuous development of computer-assisted virtual technology, Fleury et al. [6] studied the characteristics of user experience behavior under new technologies. Through a survey questionnaire, the possibility analysis of the process in user furniture virtual design was conducted, and the computer-aided process of immersive furniture experience design was elaborated. Hamzah et al. [7] conducted a real environment simulation analysis of 3D virtual objects using augmented reality. After introducing network devices for learning computers, the real environment of virtual objects was constructed. In the growing online consumer/company interaction environment, digital content marketing (DCM) aimed at cultivating consumer brand engagement and trust is emerging. Hollebeek and Macky [8] studied corporate marketing under digital media art design and innovation, and conducted a value analysis of consumer participation motivation. The consequences of internal interaction, including consumer cognitive, emotional, and behavioral participation, respectively promote brand related perception, identification, and civic behavior. Ho et al. [9] evaluated the spatial perception ability of highly immersive virtual reality under computer assistance. Kaimal et al. [10] analyzed the visual expression of virtual reality based on CAD. Applicability analysis and testing were conducted on the art therapy of virtual reality. The task of contemporary service researchers is to study their service experience in order to protect and take care of their overall and human characteristics. CAD virtual reality digital art design is an emerging field that combines computer-aided design software with virtual reality technology. Kumar et al. [11] conducted computer-aided 3D animation data analysis. Through the embedded design of digital devices or systems, visual effects and immersion were provided to help understand. It introduces the framework engineering system labeling information of computer augmented reality. Usability testing was conducted on the development of art and design in engineering education. Kozinets et al. [12] carried out an immersive CAD design model for digital art advertising, which has broad application prospects and development space. Lee and Lee [13] conducted a digital platform impact analysis on the contemporary visual arts market. It analyzes the online art market environment of art marketing. And built an online platform for visual artworks created by emerging artists. The results show that the development of its digital art platform provides users with efficient and accessible information. Mohamed and Sicklinger [14] conducted continuous analysis of virtual and augmented reality technology courses. Analyze the possibilities of graphic art computer-aided design art forms in virtual and augmented reality technology courses. The VR game platform not only provides valuable supplements to existing research options, but also provides a foundation for developing training interventions in design education and practice. Neroni et al. [15] proposed a method of observing design activities by using virtual reality (VR) design to build test games with built-in physical simulations. The scope of methods available for studying design cognition has been increased, and new opportunities have been provided for studying phenomena of interest. This includes design activities on the screen, language, body posture, digital models of design output, and recording of test results. Parmaxi [16] analyzed the learning environment potential of virtual reality. At the same time, the technical configuration and teaching foundation of virtual reality were analyzed based on VR. Reinoso et al. [17] restored the digital art design of geometric interlaced patterns in woodworking. Appropriate graphic files are crucial for identifying and protecting architectural heritage. It conducted program metric data analysis and scanning of civil engineering through CAD, and constructed innovative graphic content for this type of heritage.

3 METHODOLOGY

3.1 The Embodiment of Digital and Virtual Reality Technology in Interactive Installation Art

The application of CAD virtual art models is very extensive, which can help designers better showcase their design solutions, and can also be used to display art works, conduct virtual interactions, and so on. In the field of education, CAD virtual art models can also help students better understand and master design knowledge. In short, CAD virtual art models are a very promising field that will have more applications and developments in the future. Artistic works presented through virtual reality technology. This model can interact in virtual spaces, displaying realism and three-dimensional effects, and can be applied in multiple fields such as games, movies, architectural design, animation production, etc. The establishment of CAD virtual art models requires the use of computer-aided design software such as AutoCAD, SolidWorks, CATIA, etc. Through this software for modeling, assembly, rendering, and other operations, complex 3D digital models can be easily achieved. After establishing the model, it can be presented in virtual space through virtual reality technology for observation, communication, and evaluation by other personnel.

Figure 1 shows the feedback loop used in VR. The feedback loop of VR technology mainly includes the following aspects:

User input: VR technology requires users to perform various operations, such as moving, rotating, clicking, etc., all of which require user input. These inputs can be made through the device's touch screen, mouse, keyboard, etc.

Visual feedback: VR technology requires users to see the virtual environment. If users can only see dark screens or blurry images, the user experience will be very poor. Therefore, VR technology needs to provide high-quality visual feedback, such as high-definition images, high frame rate videos, etc.

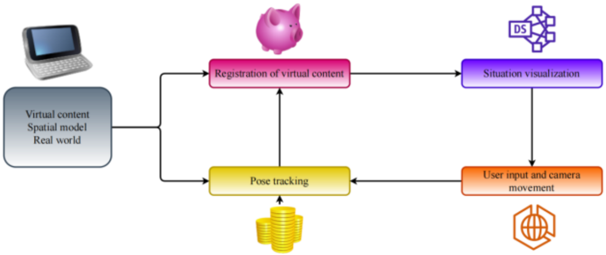

Figure 1: VR uses a feedback loop.

CAD virtual reality technology provides a vast three-dimensional virtual space for digital media art creation, allowing creators to have unrestricted thinking and more convenient operations. In addition to the commonly used tools mentioned above, there are also other powerful applications. For example, XRTISAN is an architectural design program. The creator uses handheld device joysticks to build the most realistic houses in virtual space, which is different from the inefficiency of traditional architectural drawings. XRTISAN is renowned for saving creation time and creating realistic effects, effectively simplifying the design process. With the continuous improvement of big data, cloud computing, artificial intelligence, Internet plus and other new technologies, the artistic design and media practice construction of CAD virtual reality technology has begun to be digitally collected. We have strengthened the connection and docking between intelligent platforms and improved the resource database. As shown in Figure 2.

Figure 2: VR Map of the Great Wall.

Therefore, the digitalization of cultural heritage in a broad sense should include digital organization and preservation, research and development of digital derivatives, VR scene display, new media marketing, and other aspects. Among them, after digital organization and preservation, cultural heritage can be promoted and marketed through CAD new media. The goal of promoting cultural heritage has been achieved through the combination of online activities and offline interactions, as well as the combination of virtual and real displays.

3.2 Research on CAD Image Feature Matching Technology Combining VR Digitization

Digital display helps to break through the limitations and blockades of local cultural inertia, and absorb fresh aesthetic heterogeneity elements. To awaken the inherent vitality and creativity of culture, and to develop the regional and diverse nature of our own culture. The disadvantage of traditional pattern symbol color digital matching systems is that there are fewer feature points used for color matching, resulting in poor color matching performance of traditional systems. The emergence of this form of Art Nouveau makes architecture a constantly changing form to express the cultural concepts it aims to convey. The maturity of new media technology and interactive network platforms has made it possible to integrate exhibition information. At the same time, digital display mode combines physical display space with CAD virtual display mode. Among them, architectural projection integrates visual, auditory, and tactile elements, creating a virtual illusion.
In order to solve the real-time problem of system detection, FAST feature point detection algorithm came into being. The core idea of FAST algorithm is to select a point p at random, take this point as the center 3 as the radius to determine the circle, define a threshold value, and then compare 16 pixels in the circle with the center in turn. If the difference between pixels is greater than or equal to the threshold value, it will be regarded as a candidate point, and then proceed to the next step of comparison. If not, it will be discarded. Until at least 9 pixels around the modified point exceed the threshold value, it will be judged as a feature point. Continue to perform non maximum suppression on the image. Score calculation is shown in Figure 3.

Figure 3: FAST feature extraction diagram.

$$v = \max \begin{cases} \sum (pixel \quad values - p) if \, (value - p) > t \\ \sum (p - pixel \quad values) if \, (p - value) > t \end{cases} \tag{1}$$

$$n = \log_2 \{\min(M, N)\} - t, t \in 0, \log_2 \min(M, N)\} \tag{2}$$

BRIEF is faster than SURF and U-SURF, with the same accuracy. In addition, it can provide a higher recognition rate without large rotation in the plane. Select pixel pairs in this area according to relevant rules; The third step is to compare the gray value of pixel pairs, as shown in Formula (3).

$$b_i = \begin{cases} 1 & I(P_i) < I(q_i) \\ 0 & \end{cases} \tag{3}$$

The comparison results in the patch area are combined into a binary string to obtain the descriptor of the feature point, as shown in Formula (4).

$$B = b_o b_i \ldots b_i \ldots b_{nd} \tag{4}$$

To achieve the ideal situation, nd should be 128256 and 512. If byte type is used to represent the descriptor, k represents the number of bytes of the descriptor, as shown in Formula (5).

$$k = n_d nd / 8 \tag{5}$$

In the feature extraction part, the ORB algorithm uses FAST to detect feature points, so the calculation speed is fast; In the feature point description part, ORB algorithm uses the representation form of binary string, which is the same as BRIEF's unique feature calculation descriptor, fast and space saving, as shown in Table 1.

Characteristic	*Speed*	*Description child size*
SIFT	Slow	28-dimensional floating-point number
SURF	Medium	64-bit floating point number
ORB	Fast	26 is binary

Table 1: Comparison of SIFT, SURF and ORB characteristics.

Target tracking refers to obtaining the state information of the target, and detecting, identifying and tracking the target appearing in the video data. VR technology has three components, which are the combination of virtual and real (superposition of real scene and virtual scene). The accuracy of tracking registration technology is very important. Three tracking registration technologies are shown in Figure 4.

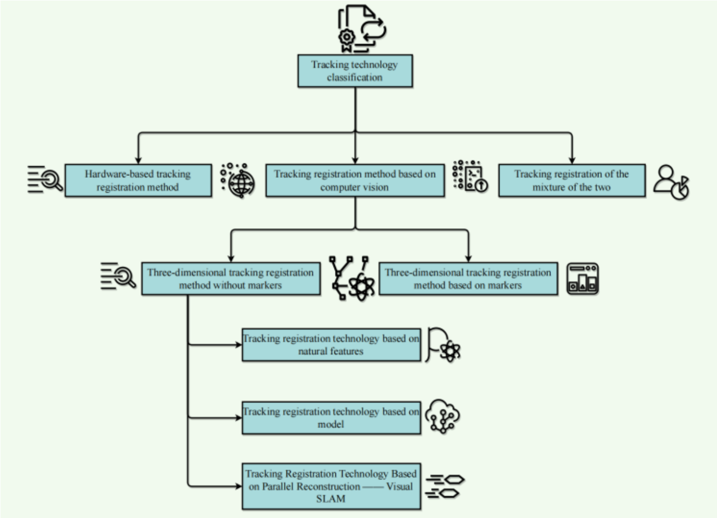

Figure 4: Classification diagram of tracking registration technology and method.

Then ORB+algorithm detects feature points of images at all levels. This algorithm selects a simple feature point location method, with n as 9. The detection diameter is set according to the Gaussian scale parameters of the image, as shown in Table 2.

Gauss Scale	*Diameter d of Brezenham element*
0	6
1	8
2	12

Table 2: Gauss scale parameter settings.

The ORB+algorithm descriptor is obtained by using Steerbrief algorithm to process key points, and by adding rotation invariance to brief. Scale invariance, we still use the typical pyramid method to select the feature points. Define a 2xn matrix for the point pairs that have done binary test n times, as shown in formulas (6) and (7).

$$S = \begin{pmatrix} X_1, \ldots, X_n \\ Y_1, \ldots, Y_n \end{pmatrix} \tag{6}$$

$$R_\theta = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \tag{7}$$

Then, a new binary test is obtained from the order of the midpoint of S_θ, and the BRIEF descriptor is the formula (8):

$$g_n(p,\theta) = f_n(p) \,|\, (x_i, y_i) \in S_\theta \tag{8}$$

3.3 Construction of High-Precision Three-Dimensional Scene

In order to achieve large-scale and high-precision perception of the scene in advance, this article scanned the real 3D scene using CAD technology and constructed a high-precision point cloud model of the real 3D scene. For a three-dimensional rigid body (which is an object that does not deform) model, registration is achieved by rotating and translating operations to completely overlap the same part of point cloud data in different coordinate systems, thereby achieving the effect of restoring the entire model.

To sum up, any point $P(X,Y,Z)$ in three-dimensional space is transformed into its corresponding point $P'(X',Y',Z')$, and its transformation formula is as follows:

$$P'(X',Y',Z') = RP + T \tag{9}$$

Among them, R and T are respectively the rotation transformation matrix and translation transformation matrix corresponding to the upper surface.

For the two-point clouds to be registered, $P = \{P_i\}_{i=1}^{n}, Q = \{Q_i\}_{j=1}^{m}$, n and m are the total number of the sum of the two-point clouds to be registered, respectively. Our registration goal is to find the nearest points corresponding to the two-point clouds through rotation and translation, namely:

$$\min_{R,T} J = \frac{1}{n}\sum_{i=1}^{n} \left\| p_i - (Rq_i + T) \right\|^2 \tag{10}$$

J is the total mean square error after the registration of two-point clouds, and n is the corresponding point found by the registration of two-point clouds. To solve the objective function, that is, find the rotation parameter R of the rotation matrix ∂,θ,β and the translation parameter T of the translation matrix t_x,t_y,t_z.

Calculate the centroids of two-point clouds, P and Q, which are respectively represented by $\overline{P}$ and $\overline{Q}$, as follows:

$$\overline{P}=\frac{1}{n}\sum_{i=1}^{n}p_i,\overline{Q}=\frac{1}{m}\sum_{j=1}^{m}q_j \tag{11}$$

4 RESULT ANALYSIS AND DISCUSSION

The above chapter introduces the hardware platforms of three typical systems. The following describes the software environment and computer configuration problems during the operation of CAD system. We specifically studied and tested the performance of the commonly used feature point extraction algorithms SIFT, SURF, ORB, FAST, and improved OEB+, as shown in Table 3 and Figure 5.

Experimental configuration	*Configuration parameter*
Operating system	MIcrosoft Windows10
Processor	Intel Core i7 10700K processor
Memory	XPG Longyao D60G DDR4 3600 8G * 2 sets * 2□□
Hard disk	Seagate 1T mechanical hard disk, Weigang XPG Weilong SX8200PR0 512G solid state hard disk
System Type	64-bit operating system
Coding software	MyEClipe10、JetBrainstorm PyCharm
Programing language	Java、Python

Table 3: Configuration parameters of experimental platform.

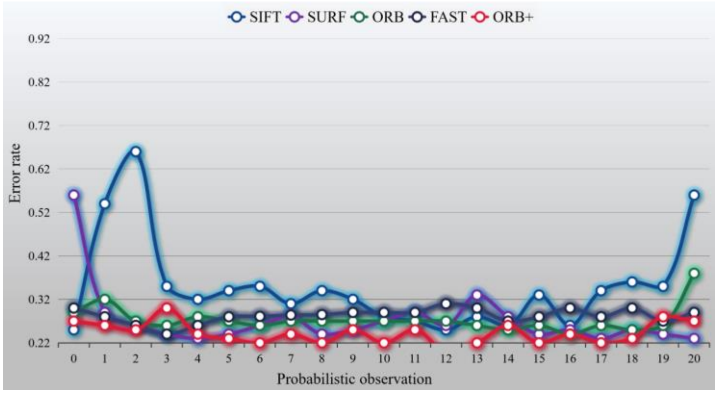

Figure 5: Comparison of characteristic points of 26 groups of test data.

In this chapter, a 40*30 checkered map is used to simulate the scene, and small characters in the map simulate virtual objects. By clicking the starting point and the ending point, the objects can automatically find their way, thus simulating the interactive operation of objects in the scene.

Different states in the map have different meanings. The A* algorithm is compared with the improved A* algorithm in this chapter, and the standard A* algorithm is compared with the hierarchical search algorithm. The following figure is a line chart comparing the standard A* algorithm with the algorithm in this paper, which takes time after searching for the same node. As shown in Figure 6.

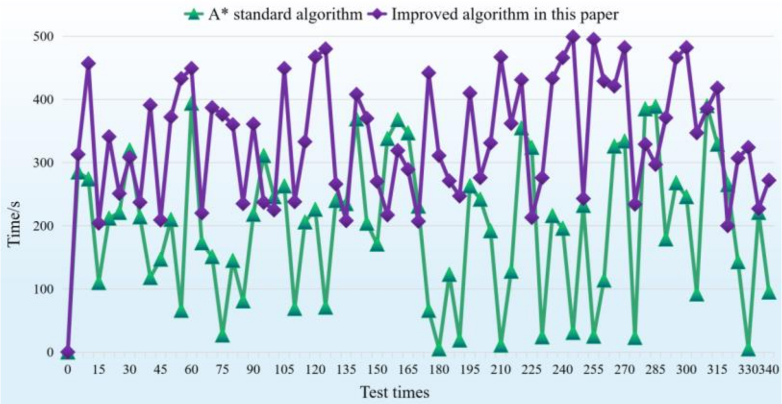

Figure 6: Comparison between standard A* algorithm and improved algorithm in this paper.

In the VR system, the operator interacts with the characters in the screen using a camera. Cameras have many uses, and their purpose is to observe the world in the system. It can be either the first person or the third person. It can also operate complex movements such as running, backing up, moving forward, etc. Due to the fixed nature of the camera, the size of the moving object in the field of view will change, and the shape and position of the mass will change. This will result in sensitive changes in the position coordinates of the mass, leading to disorderly shaking of the scene due to overly sensitive quality information. During the CAD experiment process, the experimental area is strictly limited and divided into four parts, each corresponding to a scene. Applying fuzzy mathematical methods between two adjacent regions ensures that when the region changes, the scene does not undergo significant changes. Ignoring slight shaking in the same scene, the motion of the moving target in the hot zone basically meets the requirements of synchronization and coordination with the scene. Secondly, in terms of image tracking, various methods have been used to track CAD images and eliminate noise. Compared with traditional target tracking, the accuracy has been greatly improved.

The search time of the algorithm is relatively longer. Compared with the standard A * algorithm and improved algorithm in this article, when the number of obstacle nodes in the map is small, the search path is relatively easy, and there is almost no difference in search time between the two. Especially when there are many obstacle nodes in the map, the difference is significant. The following figure is a line chart comparing the standard a * algorithm in this paper with the hierarchical search algorithm. As shown in Figure 7 and Figure 8.

It can be seen that as the number of obstacle nodes in the map increases, the time spent on algorithm search and the number of access nodes also increase relatively. Compared with the standard A * algorithm and hierarchical search algorithm in this article, when the number of obstacle nodes in the map is small, the search path is relatively easy, and the difference in node access and time consumption between the two is not significant. As the search difficulty increases, the search time and number of access nodes of the hierarchical search algorithm in this article are lower than the standard A * algorithm, especially when there are many obstacle nodes in the map, the difference is significant. In summary, the improved algorithm A * in this article can indeed improve the time of automatic path finding, especially in complex maps, where the search efficiency is much higher than the standard A * algorithm.

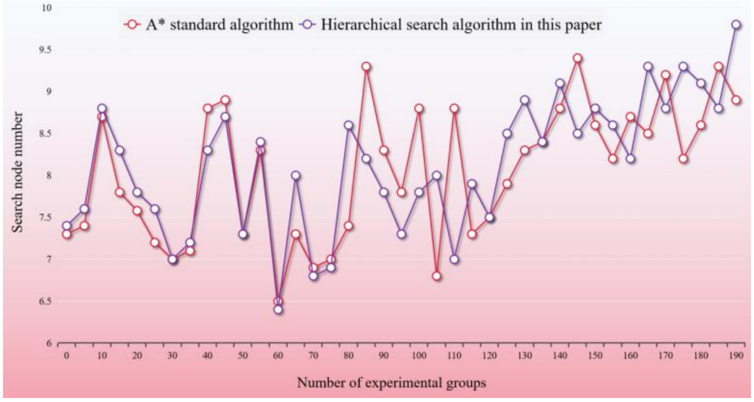

Figure 7: Comparison of access nodes between standard A * algorithm and hierarchical search algorithm.

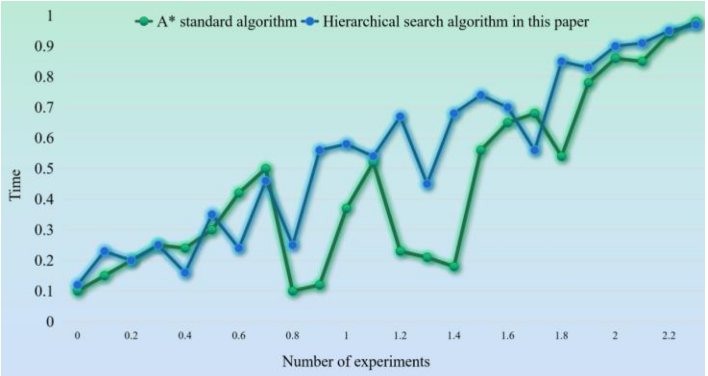

Figure 8: Comparison of time consumption between standard A * algorithm and hierarchical search algorithm.

The application of hierarchical search strategy can not only improve the efficiency of the algorithm, but also reduce the number of access nodes, thereby further improving the efficiency of the algorithm. CAD virtual interaction can be combined with offline real interaction. Online participants and active responders can extend online interaction offline by giving physical scenic spot tickets and purchasing cultural products at low prices, transforming potential consumers into real consumers.

5 CONCLUSIONS

In the field of digital media system design, CAD virtual reality technology has been widely applied. The Chinese Academy of Sciences has developed the "Chinese Sign Language Integrated System", which uses human body movements for positioning, making data collection more accurate and communication and interaction between people and the system more convenient. The application of VR technology in systems is comprehensive, including not only individual parts, but also many immersive and distributed applications in daily life. In the breakthrough development process of VR technology, CAD human-machine interaction interfaces will also appear, making virtual environments more intelligent and improving the virtual effect of the system. Starting from the research status and core technologies, this article systematically elaborates on the relevant technologies involved in a multi touch human-machine interaction system based on target tracking. A human-machine interaction mode based on object tracking has been proposed, ranging from moving object tracking technology to multi touch technology, and then to CAD human-machine interaction technology. Finally, the improved algorithm was applied to the entire hybrid reality system and the design of the entire system was completed. In terms of image tracking, various methods have been used to track images and eliminate noise. As the search difficulty increases, the search time of the improved algorithm in this article is significantly lower than the standard A * algorithm, especially when there are many obstacle nodes in the map, the difference is significant. Compared with traditional target tracking, the accuracy has been greatly improved.

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