Application Methods of Image Design Based on Virtual Reality and Interaction

Shasha Mao
College of Literature and Media, Chaohu University, Hefei, 238024, China

***Abstract*—The continuous improvement of virtual reality and interactive technology has led to a broader and deeper application in related fields, especially image design. In image design, creating usage scenarios for portable interactive experience products based on virtual reality and interactive technology can optimize and improve key parameters for real 3D techniques, thereby building a more comprehensive image design. This article constructs a three-dimensional image model of marine organisms and scenarios based on multi-sensory interactive interface generation technology and information fusion optimization ANNs-DS algorithm, targeting the image scenarios of product design. The relevant model information and parameter changes are analyzed. The results indicate that in the process of multi-sensory interface interactive image design, the virtual reality image design implemented using ANNs-DS information fusion algorithm can enhance participants' multi-sensory visual experience of the interactive interface. The reasonable degree between objects in the interactive interface and the scene space image is basically within the range of 0.85-0.95. The fluency in different scenarios can be significantly improved. Therefore, virtual reality and interactive technology have laid the foundation for developing interactive image design.**

Keywords*—*Virtual reality; interactive; ANNs-DS information fusion algorithm; image design

I. Introduction

With the continuous development of internet technology and the improvement of intelligence, the application of information technology is ubiquitous in daily life, and the development of human-computer interaction technology is also faster. Among them, virtual reality and interactive technology are also undergoing tremendous changes. It is a technology that enables dialogue between humans and computers, and its development has gradually shifted from machine-centered to human-centered [1,2]. How humans interact with computers has evolved from using traditional devices such as mice and keyboards to utilizing various sensory and action channels such as voice, gesture, posture, touch, taste, etc. In the overall development process, the interactive information changes from precise information exchange to imprecise information communication. The transformation of interaction methods has led to the development of virtual reality and interaction technology, gradually evolving from traditional command and graphical interaction interfaces to multimedia and multi-channel intelligent interaction interfaces. The essence of human-computer interaction is the process of communication and understanding between humans and computers, and a natural and harmonious interaction method has always been a pursuit in the process of human-computer interaction [3].

In the modern sense, virtual reality and interaction technology refers to the use of digital means to experience "simulated reality" and achieve a form of information exchange between people and virtual scenarios. Due to its unique characteristics and usage characteristics, it has been widely used in gaming, product display, medical, simulation training, and military simulation [4,5]. Unlike the early virtual reality before the Information Revolution and even the Industrial Revolution, humans have gradually become the main body in virtual environments, interacting with the machine environment through data gloves, helmet displays, and various information perception components and integrating into the information environment through gestures, vision, and touch.

Computer-aided image design and visual communication design based on virtual reality and interactive technology are also widely used in various industries [6,7]. This technology is widely adopted in many fields, such as the traditional film and television industry, the electronic game and advertising industry, the art industry, and even the art and design industry. Through the application and promotion of virtual reality and interactive technology, traditional image design has gradually developed into the current three-dimensional technology of three-dimensional presentation, allowing image elements to be presented in different types and forms and achieving human-computer interaction centered on humans. Therefore, with the gradual popularization of social media, people's artistic and aesthetic needs for media forms are still being satisfied with a traditional simple presentation. Instead, pay more attention to the overall sensory effect of visual communication. By optimizing design and utilizing virtual reality and interactive technology, the overall aesthetic effect, visual impact, and expressive power of image design have been effectively improved [8,9]. Virtual reality can achieve interactive visual simulation and information exchange and is an advanced digital human-computer interface technology with characteristics and advantages such as immersion, real-time, and interactivity. Therefore, it has been widely applied in different industries since its inception.

The constant maturity and development of virtual reality and interactive technology have promoted modern display art's continuous innovation and breakthrough. People are gradually beginning to use virtual reality technology in display and experience, and the immersion, interactivity, and conceptualization it brings have injected fresh blood into modern display art. In the current environment of deep integration and development of computer and virtual reality technology, humanity has entered the digital era, and interactive images have gradually penetrated people's daily work and learning. User experiences with different senses, such as vision, touch, hearing, and smell, have become a part of people's lives, demonstrating more significant advantages in engineering construction, medicine, mechanical manufacturing, and artistic creation [10-13]. In today's digital era, through the application of virtual reality and interactive technology, the interface interaction design in the image improves the effectiveness of digital products and the user experience, which has gradually become a research hotspot in the field of image design [14]. Currently, the commonly used interface generation methods in image design primarily focus on cognitive rules. However, these methods have problems, such as a low fit between the generated interface results and actual objects and relatively poor interaction effects. However, virtual reality technology is technology-centered around interactivity and immersion [15], which can effectively enhance participants' sensory experience of image design scenarios. Therefore, based on virtual reality and interaction technology, by studying and analyzing methods for designing and generating image interaction interfaces, the overall experience of image design can be improved, providing a more realistic interactive experience.

Virtual reality technology synthesizes various design methods in computer image design and visual communication design to create an artificial simulation design environment. In this illusory design environment, we can effectively simulate various system perception behaviors of humans in the natural environment. Therefore, fundamentally speaking, virtual reality technology is a modern human-computer interaction technique that can enhance the design experience of designers by optimizing the design environment and tools reasonably. At the same time, it can also enhance the visual expression and impact of computer image design and visual communication design. In the technical environment of virtual reality technology applications, it is mainly generated and controlled by computers automatically. Therefore, this technology is closely related to image design technology and visual communication design technology, which can enable participants to perceive objects in the virtual design environment in person. In the specific design process, coordination and control can be achieved through virtual and accurate technology and three-dimensional technology can be used to realistically present the object elements that exist in reality, thus achieving friendly human-computer interaction.

Based on the above analysis, the article combines virtual reality and interactive image design. It combines artificial neural network technology and information fusion optimization algorithms to construct an algorithm model for an ocean scene interactive experience. Relevant parameters are studied and analyzed for the application of the model. The algorithm's feasibility is verified by comparing it with relevant research progress [16-18], laying a foundation for further improvement of image design applications.

II. Principles of Image Design based on Virtual Reality and Interactive Technology

A. Principles of Information Collection in Virtual Reality and Interactive Technology

1) Principle of human-machine interaction in Virtual Reality technology: The application process of virtual reality technology requires the use of devices that not only rely on perceptual helmets and gloves but also include other technologies and methods related to virtual technology that have realistic simulation and authentic experience, thereby providing more sufficient guarantees and support for this process [19-21]. The implementation process of this technology mainly includes data analysis, organization and detection, data transmission, process control, virtual reality environment, and the establishment of three-dimensional scene models. Information feedback between participants and devices is also crucial for improving and enhancing the situation. Different image design processes have different requirements for collecting and processing scene information, and comprehensive analysis and research are needed for different models. Fig. 1 shows the basic principles of human-machine interaction under commonly used virtual reality and interaction technologies. Participants deeply participate in the designed image scene through relevant devices in virtual reality and interactive technology and exchange information and feedback with the virtual scene through various perception devices, thereby achieving a more realistic human-computer interaction experience.

In the early human-computer interaction technology, the main human-computer interaction methods were the mouse, monitor, and keyboard. In the specific operation process, participants edit and input information through traditional devices such as keyboards and mice and then output and receive relevant feedback from the monitor. This traditional human-computer interaction method is widely used. However, it must be addressed that this interaction method dramatically limits the scope and time of participants' digital media activities, which is not conducive to creating and constructing scenarios in human-computer interaction technology [22,23].

The development of virtual reality and interactive technology allows participants to break free from the limitations of the interactive interface of computer monitors and engage in human-computer interaction through smaller and more convenient mobile devices. In addition, from the perspective of operation methods, in addition to traditional mouse and keyboard input, users can also use their facial expressions and postures, or even EEG waves, to input information. Compared to traditional interaction methods, this type of interaction truly realizes the rapid acquisition of information and provides more significant support for constructing scene space in virtual reality technology.

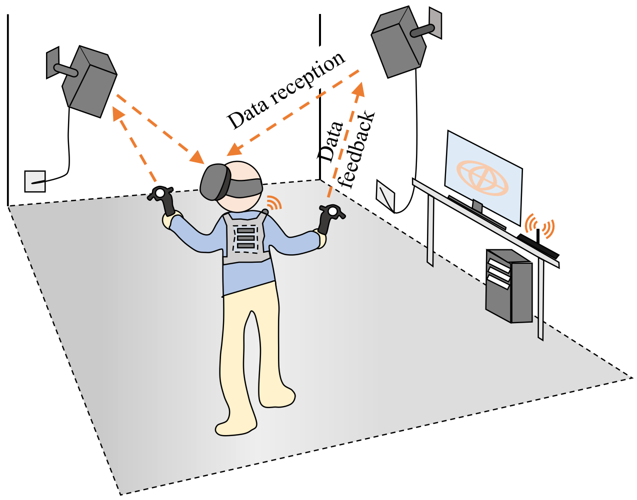


Fig. 1. Principle of human-computer interaction under virtual reality and interaction technology.

2) Principles of information collection in Virtual Reality and interactive technology: In the application of virtual reality and interactive technology, to conduct a detailed analysis of images and organize data for higher precision designs, it is necessary to collect and process the sound field synthesis information of images [24], to obtain an effective data set. Therefore, it is necessary to analyze the information acquisition in this process. First, the Fourier transform function is used to realize the conversion process of the sound field synthetic wave function. Then, based on the conversion results, the phase difference between a certain collection point in the sound field synthetic wave and the emission point of the sound field wave information is comprehensively analyzed, and the emitted sound field information and received sound field information are obtained using the phase difference. Based on this information, function processing and analysis are performed. Finally, the final collection result of the virtual reality sound field synthetic information is obtained based on the obtained information [25]. In this process, the Fourier transform is used to redefine the sound field composite wave function: it is expressed as a state of superposition of many single frequency waves [26], and the sound field composite wave function is shown in equation (1):

$$X(k)=\sum_{n=1}^{N} x(n)\times e^{\frac{2\pi}{N}(n-1)\times(k-1)} \tag{1}$$

Equation (1), $X(k)$ represents the value of the sound field composite wave function, N represents the number of sound field composite information, and n represents the number of time series of sound field composite information. $x(n)$ represents the time series of sound field synthesis information, and k represents the number of elements in the sound field pulse wave function. In addition, by performing Fourier transform on the parameter $x(n)$ involved in equation (1), equation (2) can be obtained:

$$x(n)=\frac{X(k)}{\sum_{n=1}^{N/2}\cos\left(\frac{2\pi k}{N\mathrm{d}t}\right)} \tag{2}$$

In addition, using equation (2) for analysis, the *k-th* harmonic emission sound field information can be obtained, and the relevant model can be expressed as equation (3):

$$\mathrm{d}_1(k,x)=\frac{\cos\Delta\varphi_{i1}+sin\Delta\varphi_{i1}}{2N} \tag{3}$$

Based on the analysis of the above principles, equation (4) can be obtained for receiving sound field information in the same way:

$$\mathrm{d}_2(k,x)=\frac{\cos\Delta\varphi_{i1}+sin\Delta\varphi_{i1}}{S} \tag{4}$$

Because the synthesized sound field information can be represented as the superposition of many single-frequency waves, the synthesized sound field information in virtual reality is formed by the superposition of the sound fields generated by each single-frequency wave. Based on the above analysis, adding all $\mathrm{d}_1(k,x)$ one by one can obtain the total emitted sound field $D_1(x)$, as shown in equation (5):

$$D_1(x)=\sum_{K=1}^{N/2}\mathrm{d}_1(k,x) \tag{5}$$

Similarly, by adding all $\mathrm{d}_2(k,x)$ the total received sound fields can be obtained, as shown in equation (6):

$$D_2(x)=\sum_{K=1}^{N/2}\mathrm{d}_2(k,x) \tag{6}$$

Based on the above analysis, it can be seen that when collecting sound field synthesis information in virtual reality, the original data signal of the sound field is obtained through the microphone array system, and the relevant information of the scene is obtained through the Euler angle multi-data fusion, providing more comprehensive design primary data for influencing design. In the process of information synthesis, the primary method is to obtain the newly generated sound signal data by performing Fourier transform on the function values and performing the inverse Fourier transform on the newly generated signal to obtain the collection results of the virtual reality sound field synthesis information [27,28]. In the specific implementation process, microphone arrays can be applied to speech data processing and are arranged according to specific arrangement rules in the microphone system. This system has the characteristic of spatial selectivity, which can suppress the noise in the surrounding environment to a certain extent, thereby ensuring the stability of relevant feature parameters in the collection and processing process without data damage.

B. Information Processing in Image Design

The connotation and extension of virtual reality technology are constantly changing, accommodating more related technologies and imaging environments more openly. The continuous application and rapid promotion of virtual reality technology have also promoted the continuous updating and development of human-computer interaction technology and laid a technical foundation for building more expected virtual reality scenarios. The human-computer interaction technology based on virtual reality refers to the technology of achieving a more effective dialogue between humans and computers through computer input and output devices, based on virtual reality technology. In the human-computer interaction technology of virtual reality, participants can not only obtain a large amount of relevant information and prompts through machines or related display devices and input relevant information and prompts through input devices. In addition, the interaction process between humans and machines also involves inputting relevant information and answering questions to the machine through input devices. As one of the essential contents of image design [29], human-computer interaction technology is closely related to cognitive science, ergonomics, psychology, etc. Fig. 2 shows a virtual reality system's main composition and basic process.

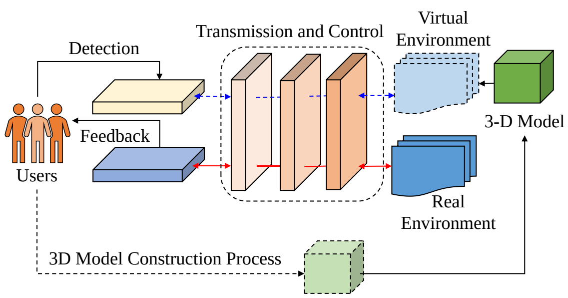


Fig. 2. Composition of virtual reality system.

In applying impact design based on virtual reality and interaction, an algorithm based on a combination of essential probability allocation functions is used in multi-sensory information fusion [30]. After processing the corresponding information numbers, Set s sensory input modules to generate s linearly independent sensory feature vectors. These sensory feature vectors allow neural network algorithms to identify *n* targets. Due to the lack of correlation between network complexity and the number of input units within neural network algorithms, it is difficult to accurately determine the number of hidden layers within the network and the number of neurons within different hidden layers, and it is not possible to ensure complete convergence during network training. Therefore, when using neural network algorithms to fuse multi-sensory information, combining them with information fusion algorithms is necessary. The detailed process description process involves using $(v_1, v_2, \ldots, v_e)$ to represent e sensory feature vectors, implementing reasonable and practical classification combinations for $(v_1, v_2, \ldots, v_e)$, and dividing them into q groups, where q should be within the range of 1≤q≤e. Include e in each group separately e_i vectors, which can be represented as $(v_1^i, v_2^i, \ldots, v_e^i)$, where $v_j^i \in (v_1$, $v_2, \ldots, v_e)$, thus ensuring the integrity of multi-sensory information.

In addition, it is necessary to design a neural network with e_i (i=1, 2, 3, …, q) inputs and n outputs, and generate relevant learning models based on the expert knowledge between the current multi-sensory feature vectors and the targets. These targets belong to the multi-sensory information fusion structure, and the non-linear mapping between the trust levels of the e_i (i=1, 2, 3, …, q) multi-sensory feature vectors and the n targets to be identified is completed. Each analysis for different senses is divided into q pieces of evidence. Taking the i=1, 2, 3, …, q pieces of evidence as an example, it contains e_i multi-sensory feature vectors, and each target is a proposition of this evidence. Therefore, it is determined that each piece of evidence has n propositions.

The sampling period of multi-sensory information is represented by T, at lT, for the i-th evidence, a neural network with e_i inputs and n outputs designed using the above process can obtain n values between 0 and 1. This value serves as the credibility of this evidence for different propositions and is recorded as CF. The closer the n CF values here are to 0.5, the lower the discriminability of the evidence for the target. After computing n CF values with the Gaussian function $x^{-\left(\frac{x-1/2}{\delta}\right)^2}$ relevant data results can be obtained after computing all pieces of evidence at the lT moment.

III. Algorithm for Generating Scenes in Virtual Reality and Interactive Technology

The image design and construction process based on virtual reality and interactive technology can generally be divided into two stages: the design content stage and the multi-sensory experience stage. As shown in Fig. 3, the interaction between the two links is shown. Among them, the design content process can be divided into two parts: visual information design and interaction mode design. The interactive interface layout design and interface content design are completed through the design content; the multi-sensory experience process can be divided into three parts: cognitive experience, emotional experience, and sensory experience. Based on the layout design of the interactive interface and the design of the interface content, the interaction mode design in the design content process is combined to enhance participants' multi-sensory visual experience of the interactive interface.

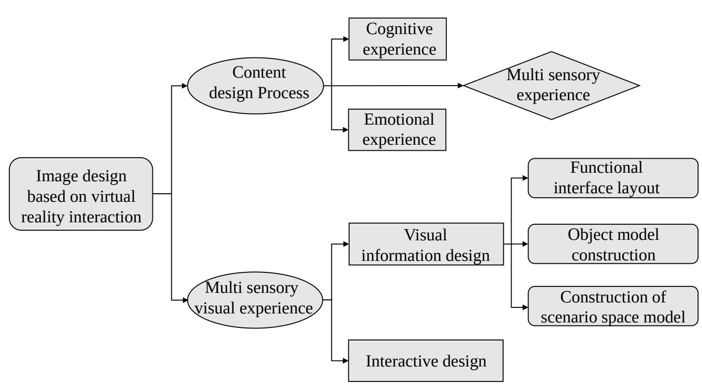


Fig. 3. Generation process of multi-sensory interactive interface based on virtual reality.

A. *Interface Generation Process Based on Virtual Reality and Interactive Technology*

1) Content and links of image design: In image design, visual information design is central to generating multi-sensory interactive interfaces based on virtual reality. Visual information design consists of three parts: functional interface layout, three-dimensional object model construction, and scene space model construction. The functional interface design is completed using an interactive interface layout optimization model. This model is based on the interface visual attention partitioning model and the results of functional criticality analysis. The optimization objective function is set as the optimal visual attention partitioning for the final layout of the interactive interface [31], in order to construct a functional interface layout optimization model based on visual attention partitioning. The following definition is adopted for the optimization model of functional interface layout based on visual attention partitioning [32]:

a) The set $\{a_{ij}\}$ represents the visual attention level of the units occupied by a certain functional module in the visual area with different levels, where a_{ij} represents the visual attention level of the unit occupied by functional module *i* in the visual area *j*.

b) The visual attention level of the visual area where the central coordinate of a certain functional module is located is represented by the set $\{s_{ij}\}$, where s_{ij} represents the visual attention level when the center coordinate of functional module *i* is in the visual distance region *j*.

c) The set $\{d_{ij}\}$ represents the number of units that a certain functional module occupies within the visual expectation of varying levels, where d_{ij} represents the number of units occupied by functional module *i* in the visual area *j*.

Determine the criticality of different functional modules in the functional interface and compare them. Use w_k to represent the criticality of module u_i. equation (7) can be used to describe the relative criticality of functional modules:

$$r_k = \frac{w_{k-1}}{w_k} \tag{7}$$

By using equation (8), the criticality of functional module u_i can be determined:

$$w_i = \frac{1}{1+\sum_{k=2}^{n}\prod_{i=k}^{n} r_i} \tag{8}$$

Describe the intensity of visual attention division using equation (9):

$$Z = \sum_{i=1}^{n}\sum_{j=1}^{3} w_i a_{ij} s_{ij} d_{ij} \tag{9}$$

The upper limit of visual attention division intensity is represented by *Y*. That is, $Z_{max} = Y$, from which equation (10) can be obtained:

$$Y = max\left(\sum_{i=1}^{n}\sum_{j=1}^{3} w_i a_{ij} s_{ij} d_{ij}\right) \tag{10}$$

Select particle swarm optimization algorithm to solve the functional interface layout optimization model based on visual attention partitioning [33], and complete the functional interface layout. Generate the required image information for different areas in the functional interface through 3D model construction.

2) Model construction in image design: The image information in images based on virtual reality and interactive technology includes 3D objects and scene space, which are generated using 3D model construction methods. In model construction, for scenario spaces with complex structures, differences can be applied to obtain several scenario space units, and different modeling methods can be used to synthesize the scenario space units into a whole, constructing a three-dimensional model of the scenario space. In addition, for the scene rendering process, after simulating the lighting in the scene space and setting proper lighting, the scene space is rendered to adjust the brightness and position of the lighting continuously. Optimize the scene space for the interaction process in the scene space, determine whether collision detection is necessary according to actual application needs, and reduce the visual memory consumption of texture maps by compressing textures to determine the balance between virtual scene space and roaming interaction smoothness.

As mentioned above, in image design, the image information of relevant images is generated using the 3D model construction method: one needs to model the objects in the 3D image. In this process, the relevant data collection process is imported into the software to obtain a floor plan, and the objects are adjusted and optimized based on the relevant information of the obtained scenario; For scenario spaces with complex structures, differentiation can be applied to obtain several object units, which can be combined into a whole to construct a three-dimensional model of the scene image. Secondly, texture mapping is required. In order to improve the realism of the scene in the process of image design and enhance the authenticity of image design, it is necessary to use the material editor to implement texture mapping processing on objects. Different surfaces of a scene space need to map different textures. Under this condition, you must use multi-dimensional material objects to load several maps for different materials under the explicit material to achieve different texture mapping ideas. In addition, in image design, it is also necessary to pay attention to improving scene rendering and baking effects. After simulating the sunlight illumination in the scene space and setting proper lighting, the scene space is rendered, and the brightness and position of the lighting are continuously adjusted to achieve the optimal rendering effect. After completing the rendering, bake it reasonably to store the data of the object image design rendering results. Finally, to achieve a sense of virtual reality experience for participants, it is necessary to interact with the scene in the image design space. Through the preliminary work, the walking camera and flying camera in the scene space are created respectively in the process of image interaction design to simulate the height and change speed of the image under the walking condition of the participants. In this process, it is also necessary to determine whether collision detection is necessary based on actual application needs. The balance between virtual image design space and roaming interaction smoothness needs to be determined by compressing textures to reduce the graphics memory consumption of texture maps.

B. ANNs-DS Algorithm Based on Information Fusion Optimization

The ANNs-DS information fusion algorithm based on a combination of essential probability allocation functions is used in multi-sensory information fusion. Assuming that s sensory input modules are processed with corresponding information numbers to generate s linearly independent sensory feature vectors, based on these sensory feature vectors, neural network algorithms can identify n targets [32]. Due to the lack of correlation between network complexity and the number of input units in artificial neural network algorithms, it is difficult to accurately determine the number of hidden layers in the network and the number of neurons in different hidden layers, and it is not possible to ensure complete convergence during the network training process. Therefore, when using neural network algorithms to fuse multi-sensory information, combining them with the DS algorithm is necessary to form an ANNs-DS algorithm based on information fusion optimization. Among them, in the artificial neural network algorithm process, different parameters are input at the input layer. Then the relevant parameters enter the hidden layer for data analysis and operation. The data is mined and analyzed through this layer, and then the relevant demand parameters are sorted and output through the output layer. In generating visual interaction interfaces based on virtual reality and interactive technology, the actual sensory information received by participants is a crucial consideration.

Based on the above analysis, an information fusion optimization algorithm (ANNs-DS) was constructed based on Artificial Neural Networks technology and Dempster Shafer's theory to maximize the consideration of participants' actual sensory acceptance of information. This platform takes sensing, body sensation, and visual information as input information and utilizes the ANNs-DS information fusion algorithm for multi-sensory visual information fusion. Based on relevant fusion results, interface interaction functions such as displaying virtual reality images, odor generation, vibration, and sound feedback are achieved. The processing process of multi-sensory visual experience elements using virtual reality and interactive technology based on the ANNs-DS algorithm is shown in Fig. 4.

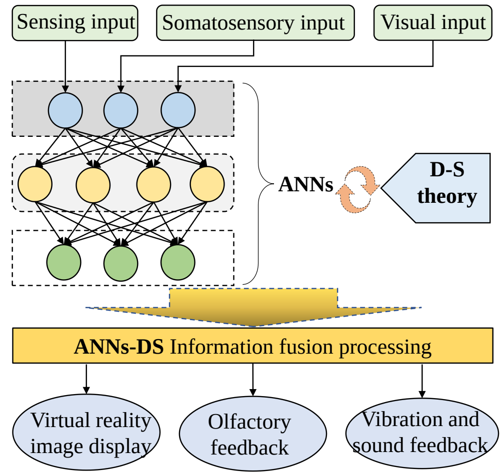


Fig. 4. ANNs-DS Information fusion algorithm principle and multi-sensory visual experience process.

From a temporal perspective, the specific process of multi-sensory visual information fusion is as follows: set the period to T, and use $m_{i,1}(k-1), m_{i,2}(k-1), \ldots, m_{i,n}(k-1)$ to represent the fusion result of multi-sensory visual information in the time domain corresponding to the *i-th* neural network at the (k-1) T moment. Under the condition of reaching the subsequent time kT, its basic probability distribution function and solvability level can be expressed as $m_{i,j,k}(\text{where } j=1,2,\ldots,n)$ and $\delta_{i,k}$, respectively. The fusion process in the time domain under the kT time condition is obtained from equations (11), (12), and (13):

$$m_{i,j}(k) = \frac{m_{i,j}(k-1)m_{i,j,k} + m_{i,j}(k-1)\delta_{i,k} + \delta(k-1)m_{i,j,k}}{1-P_{i,k}} \tag{11}$$

$$\delta_i(k) = \sum_{j=1}^{n} m_{i,j}(k) \tag{12}$$

$$P_{i,k} = \sum_{j \neq 1} m_{i,j}(k-1) m_{i,j,k} \tag{13}$$

From a spatial perspective, the specific process of multi-sensory visual information fusion is as follows: using mutual fusion between two pairs to target $m_{i,1}(k), m_{i,n}(k), \ldots, m_{i,n+1}(k)$ is combined to perform spatial fusion on the time fusion results of two neural networks, and the obtained spatial fusion results are refused with the time fusion results of the third neural network. By iterating the above results, the basic probability distribution function for the *j-th* target after kT time is obtained as $m_{q,j}(k)$, and then we obtain equations (14) and (15):

$$m_j^q(k) = m_j(k) \tag{14}$$

$$\delta(k) = 1 - \sum_{j=1}^{n} m_j(k) \tag{15}$$

Based on the above process, it can be obtained that after passing through *kT* time, the final decision level and the unsolvable level of the *j-th* target for multi-sensory visual information fusion are $m_j(k)$ and $\delta(k)$, respectively. From this, the final multi-sensory visual information fusion result can be obtained based on $m_j(k)(\text{where} j=1,2,\ldots,n)$.

IV. Application of Virtual Reality and Interactive Image Design

A. Application of ANNs-DS Algorithm in Image Design

To verify the application performance of the image interaction interface generation method based on virtual reality and interaction technology, a wearable interactive experience product was designed. The ANNs-DS information fusion algorithm was used to generate the interaction interface of the application objects in the image design, and the specific performance was tested. In the process of generating interactive interfaces in image design, the interactive experience of building a 3D model is shown in Fig. 5. Based on the relevant information on marine organisms obtained, a three-dimensional model of the ocean interior can be effectively constructed, which can significantly improve the authenticity of ocean scenarios, as shown in Fig. 5(A). In addition, by constructing an information model between participants and the ocean scenarios, the sense of integration of participants' experiences can be increased, as shown in Fig. 5(B). The interaction and information fusion of image design for A and B in the Fig. 5, as well as scene rendering through adjusting the brightness and position of the lights, can further improve the authenticity of the model, as shown in C in the Fig. 5. Through the interactive interface constructed in image design, participants can overlook the target through a flying camera and adjust visual proximity through information exchange. The above analysis indicates that in the interactive interface constructed using this algorithm, virtual reality technology is used to provide participants with an immersive roaming experience while enhancing their experience through different senses, such as vision and hearing.

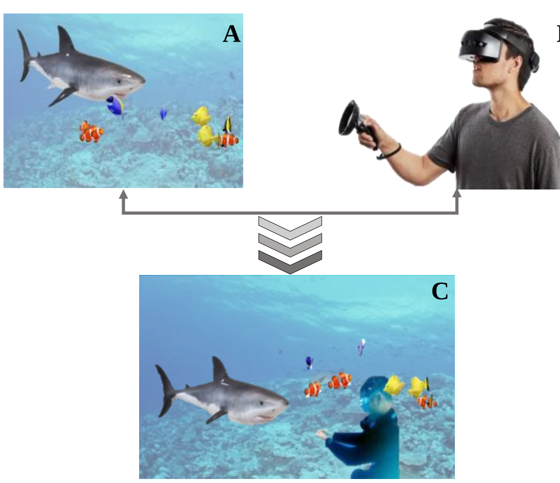


Fig. 5. Construction of scenario space based on virtual reality and interaction technology.

B. Analysis of Similarity of Interactive Interface

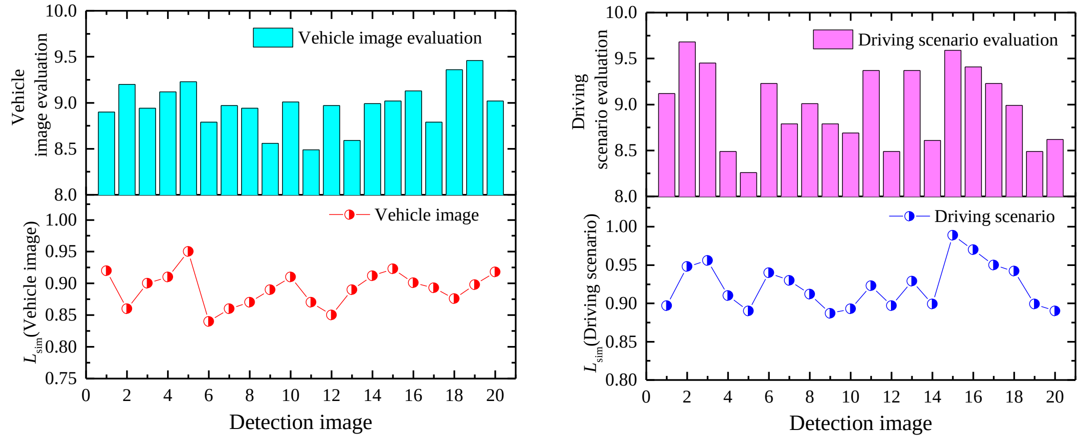
In image design, the similarity degree between virtual objects and scene space in the interactive interface is an important evaluation indicator for the effectiveness of interactive interface design. The similarity degree calculation process is as follows:

$$L_{sim} = 1 - \frac{1}{N} \times \sum_{i=1}^{N} (|h_i - f_i| / 255) \tag{16}$$

In equation (16), N represents the number of pixels in the interaction interface object and scene space image. h_i and f_i represents the pixel values of the *i-th* pixel in the actual object and scene space images, as well as the designed interactive interface object and scene space images. The fair value is 0-1, and 1 indicates that the object and scene space images in the designed interaction interface are entirely consistent with the actual object and scene space images. Randomly select 20 images of marine organisms and 20 images of seabed scene space from the generated application object interaction interface, and calculate the fitting results of all images, as shown in Fig. 6. Fig. 6 shows that the fit between the marine biological images and the seabed scene space images generated by the ANNs-DS information fusion algorithm in the interactive interface is above 0.8, with a maximum of 0.98. As shown in the gray area of the figure, there are 18 marine life images with a reasonable degree between 0.85 and 0.95, accounting for 90%; The number of seabed scenarios with a fair degree between 0.85 and 0.95 is 17, accounting for 85%. According to the 10-point evaluation standard, evaluate marine biological images and seabed scenarios based on participants. The results are shown in Fig. 6(a) and 6(b), with an average score of 9.0 for benthic biological imaging; the average score for the underwater scenario is 8.9 points, both of which have higher scores. Therefore, based on the above analysis, it can be seen that the ANNs-DS method in this article generates an interactive interface with high fitting and accuracy, which can provide participants with a more realistic sensory experience.

C. Testing of Interactive Interfaces in Image Design

In the above image design based on virtual reality and interactive technology, the interface conversion time and image design accuracy of the interactive interface generated by the ANNs-DS information fusion algorithm under different concurrent participant numbers in Fig. 7. As shown in the figure, with the gradual increase in concurrent users, the time required to convert all functional interfaces within the generated interactive interface shows a gradual upward trend. Among them, the time required for the interface login function is significantly higher than that for underwater scene space selection, biological type selection, and camera selection. When concurrent users reach 120, the interface conversion time is around 1260ms. The accuracy analysis of the image is within the range of 89.6% to 96.0%, which has a high design accuracy. This indicates that the interactive interface generated by this method still has good interface conversion smoothness and design accuracy even under a large number of concurrent users.



(a) Fit of marine organism and evaluation scores. (b) Fit of ocean scenarios and evaluation scores.

Fig. 6. Similarity analysis of test images in image design.

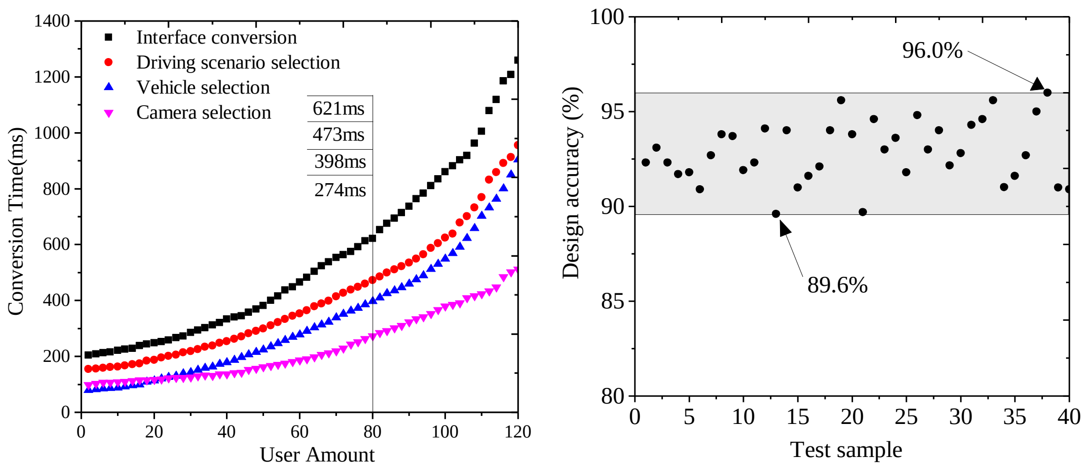


Fig. 7. Interface conversion time test under different impact scenarios.

V. Conclusion

The continuous development and application of virtual reality and interactive technology have promoted continuous innovation in image design from a technical perspective. This article is based on applying virtual reality and interactive technology in image design, combined with the ANNs-DS information fusion optimization algorithm, to construct a three-dimensional interaction model of images in ocean scenarios. The relevant parameters of the model were studied and analyzed for different scenarios, and the changes in fitting and smoothness of the three-dimensional model in image design were given. The main conclusions are as follows:

1) The image design combining virtual reality and interactive technology can integrate multiple sensory information to create and construct three-dimensional image scenes. In the process of multi-sensory visual design, the ANNs-DS information fusion algorithm is used to integrate sensing information, tactile information, and visual information, achieving interactive functions such as virtual reality image display, vibration, and sound feedback, which can effectively enhance participants' multi-sensory visual experience of the interaction interface.

2) Through the analysis of the interactive image design process for ocean scenarios, the fitting degree between the ocean biological images and the ocean scene spatial images generated by the fusion algorithm in the interactive interface is above 0.8. Among them, the proportion of marine biological types with a fitting degree between 0.85 and 0.95 is 90%; the proportion of ocean scenario fit between 0.85 and 0.95 is 85%.

3) The interactive interface generated using the ANNs-DS algorithm has certain advantages in interface conversion time under different concurrent user numbers. As concurrent users gradually increase, the time required for interface conversion shows a gradual upward trend. Among them, it still has good interface conversion smoothness even when the number of concurrent users reaches 120, and the interface conversion time is around 1260ms.

4) Combining the current research results and the current industry research progress, the later research can combine virtual reality and interactive technology to conduct research in product design, 3D printing, and other fields and combine user experience to conduct deeper interaction Experience design, to meet the deepening application of this technology better.

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REFERENCES

[1] W. Zhao, S. Zhang, X. Li, Impact of virtual reality technology on digital media in the context of big data and artificial intelligence, Journal of Computational Methods in Sciences and Engineering 23(2), (2023).

[2] Z. Y. Huo, X. W. Luo, Q. Wang, V. Jagota, M. Jawarneh, M. Sharma, Design and simulation of vehicle vibration test based on virtual reality technology, Nonlinear Engineering 11(1), (2022).

[3] M. M. Scheunemann, C. Salge, D. Polani, et al., Human perception of intrinsically motivated autonomy in human-robot interaction, Adaptive Behavior 30(5), (2022).

[4] S. J. Du, Application Analysis of Virtual Reality VR Technology in Art Design Teaching, Journal of Physics: Conference Series 1881(2), (2021).

[5] M. Y. Lee, A Study on the Satisfaction of Basic Medical Class Applying Virtual Reality (VR). Journal of the Korea Entertainment Industry Association 13(7), (2019).

[6] Z. Q. Wang, L. H. Lu, Research on application of virtual reality technology in visual optimization of plane advertisement, Modern Electronics Technique 43(24), 149-151+155 (2020).

[7] L. B. Wan, Application of virtual reality technology in visual optimization of industrial design, Modern Electronics Technique 43(16), 156-158 (2020).

[8] B. Sun, On the Aesthetic Characteristics of Virtual Reality Art, China Television 404(10), 74-77 (2019).

[9] R. Diodato, Virtual Reality and Aesthetic Experience, Philosophies 7(2), (2020).

[10] N. Guo, T. M. Wang, L. Hu, et al., Human-Computer Interaction Technology for ACL Reconstruction Surgical Navigation System Based on AR, Computer Engineering and Applications 964(21), 230-236 (2020).

[11] D. J. Wang, Research on technology of virtual reality system for practice of engineering surveying, Geotechnical Investigation & Surveying 39(12), 55-58+66 (2011).

[12] J. W. Song, Y. H. Hou, L. J. Wang, P-2.4: Development and Prospect of Medical Action Recognition Technology for Virtual Reality (VR), SID Symposium Digest of Technical Papers 53(S1), (2022).

[13] M. Aghapour, B. Bockstahler, State of the Art and Future Prospects of Virtual and Augmented Reality in Veterinary Medicine: A Systematic Review, Animals 12(24), (2022).

[14] Y. T. Feng, Z. H. Yang, J. R. Song, Multi-Sensory Product Design for the Visually Impaired under the General Vision, Packaging Engineering 420(06), 123-127 (2020).

[15] B. Cai, W. H. Zhu, H. L. Gu, Factory layout and roaming system based on virtual reality technology, Management and Informatization 81(3), 145-148 (2019).

[16] S. J. Lu, Abozinadah Ehab, Erkec Elif. Image design and interaction technology based on Fourier inverse transform. Applied Mathematics and Nonlinear Sciences, 7(2), 493-502 (2021).

[17] Y. H. Zhang, Y. H. Zhang, X. Y. Wang, Research on the Visual Interaction Design of Tourism Destination Brands Based on Regional Features. Journal of Physics. Conference series, 1634(1), 1-6 (2020).

[18] Duan He, Z. H. Hu, X. H. Hao, H. Shen, Design and Implementation of Fast Interpretation System for High-Resolution Remote Sensing Images. Computer Applications and Software, 40(3), 17-21 (2023).

[19] D. Lei, S. H. Kim, Application of Wireless Virtual Reality Perception and Simulation Technology in Film and Television Animation, Journal of Sensors (2021).

[20] L. L. Li, X. Y. Zheng, The Study of Virtual Reality Sensing Technology in the Form Design and Perception of Public Buildings, Journal of Sensors (2022).

[21] L. L. Liu, Virtual reality-based collaborative product appearance design under human-computer interaction, Modern Electronics Technique 41(07), 111-114 (2018).

[22] D. Ververidis, S. Nikolopoulos, I. Kompatsiaris, A Review of Collaborative Virtual Reality Systems for the Architecture, Engineering, and Construction Industry, Architecture 2(3), (2022).

[23] L. Ying, Y. G. Hui, P. X. Dao, et al., Application Research on Virtual Reality Technology, Applied Mechanics and Materials 3468, 644-650 (2014).

[24] J. H. Pan, X. Deng, Multi-source information art painting fusion interactive 3D dynamic scene virtual reality technology application research, International Journal of Communication Systems 35(5), (2020)

[25] L. Hao, W. J. Chung, Human-Machine Interface Visual Communication Design Model of Electronic Equipment Using Machine Vision Technology, Wireless Communications and Mobile Computing (2022).

[26] Y. W. Huo, W. Xu, Y. L. Li, J. Tao, Virtual Reality Sound Field Synthesis Information Acquisition Modeling Simulation Analysis, Computer Simulation (2016-18), 135-136 (2019).

[27] Y. Wang, Successful Application of Virtual Reality Technology in Improving the Interactive Mode of Digital Media, Digital Technology & Application 9(36), 198-201 (2021).

[28] H. J. Cui, M. H. Cheng, Teaching Strategies of Digital Media Art Based on Virtual Reality Technology, Journal of Shanxi University of Finance and Economics 44(S2), 125-127 (2022).

[29] C. Q. Li, Analysis of the Changes in the Interactive Mode of Digital Media by Virtual Reality Technology, Art Science and Technology 31(04), 47 (2018).

[30] S. Yan, Exploration and Research on Innovative Teaching of VR Interaction Design Guided by Design Thinking, Chinese Art (5), 106-113 (2019).

[31] C. X. Pan, X. Y. Wang, W. R. Zhang, Research on Immersive Interactive Design of Medical Anatomy Teaching Based on Virtual Reality Technology, Art & Design 323(03), 68-71 (2020).

[32] J. Q. Mei, Q. Cheng, Multi Sensory Visual Interactive Interface Generation Method Based on Virtual Reality, Computer Simulation 39(09), 212-216 (2022).

[33] H. Yuan, C. C. Lao, Q. L. Zhang, et al., Design of Industrial Servo Press Touch-type Interactive Interface Based on User Experience, Packing Engineering 40(12), 229-235 (2019).