www.cad-journal.net
Computer-Aided Design AND APPLICATIONS

Optimization Strategy for Visual Communication Design Using CAD and Multi-Agent Systems

Min Zhang

College Of Art, Zhengzhou University Of Science And Technology, Zhengzhou 450064, China, 123971314@zit.edu.cn

Corresponding author: Min Zhang, 123971314@zit.edu.cn

Abstract. With the rapid development of computer technology and the digital age, the field of visual communication design needs to meet people's needs for modern life. As a means of information and data dissemination in the market-oriented development of art, it has been impacted and influenced by high-tech. The design products of visual communication have gradually shifted from traditional flat and singular styles to three-dimensional virtual reality displays. Due to the need for visual communication, design works in the digital age to present rich and diverse, bold colours, and innovative display concepts. We utilize CAD technology and multi-agent systems to optimize and innovate visual communication design. This article first starts from the core functions of CAD computer-aided design technology and explores the development trajectory of this technology. Innovate and optimize two-dimensional animation in visual communication design to create a three-dimensional rendering visual communication effect. Secondly, with the help of CAD technology, research is conducted on dynamic visual communication design concepts, and in-depth analysis is conducted on the presentation methods of visual elements. Finally, CAD technology is combined with multi-agent systems to construct a visual communication design optimized display space, and virtual reality scenes are applied to the visual communication-optimized design works. Research shows that the combination of CAD computer-aided technology and multi-agent systems can make visual communication design works more three-dimensional and spatialized, meeting people's modern needs for information media.

Keywords: CAD Technology; Multi-Agent Systems; Visual Communication Design; Design Optimization; Virtual Reality
DOI: https://doi.org/10.14733/cadaps.2024.S26.202-216

1 INTRODUCTION

The rapid development of computer and multimedia technology has brought new changes to art design and visual communication design. Multi-agent systems, as an effective distributed coordination and decision-making method, are widely used in the communication information management of smart grids. Azeroual et al. [1] conducted a performance analysis of multi-agent information management in the field of machine vision. It has conducted personalized visual construction by analyzing the network performance of device control. Through research on network tomography technology, a visual information detection path generation algorithm has been implemented based on a linear system model. The information orbit-related parameters calculated by the SGP4 model library are provided through TLE data and Python scripting language. According to the CZML language specification and the SSE technology provided by HTML5 for data transmission. Reuse the Cesium digital earth platform to achieve communication information orbit simulation and visualization, and display the results calculated by fault scanning technology together. Experiments have shown that in communication networks, the algorithm proposed in this paper can measure all link performance indicators with as few detection paths as possible while meeting time requirements. Finally, combining Cesium, an open-source 3D library, to build a visualization platform. Visualize the network topology and detection path strategy. Bao et al. [2] designed a universal communication multi-agent reinforcement path planning algorithm for the combination of decentralized path planning strategy and communication mechanism. The impact of different communication designs on the pathfinding strategy was experimentally compared, providing a theoretical and experimental basis for subsequent work. Learn the overall optimal priority allocation by learning priority information from expert strategies. Guided by this priority information, a dynamic decentralized topology communication architecture is constructed to achieve communication learning with collaborative avoidance capabilities. In response to the challenges in large-scale scenarios, this article introduces the idea of mean field based on the PICO algorithm, approximating the distribution of observation information in large-scale testing scenarios to that in small-scale training scenarios. This enables the strategies obtained from small-scale scenario training to be applicable to large-scale testing environments. Simultaneously, using the large-scale reinforcement learning framework MAgent to optimize inference efficiency. Dev et al. [3] explored the optimization method and application of green communication in the Internet of Things based on CAD multi-agent optimization. By simulating and analyzing multi-agent models, understand the communication behaviour and influencing factors between different agents.

Traditional graphic design has significant limitations on information, and many 3D content cannot be displayed and processed using ordinary visual communication design effects. The dissemination of static information can no longer meet the needs of the public for modern life. Therefore, diversified visual communication concepts and design schemes have become the mainstream direction of visual design. Guo and Ma [4] explored new methods, applications, and potential impacts of product visual communication in virtual reality environments based on computer-aided technology. As an important tool in modern design, computer-aided technology can accurately perform tasks such as 3D modelling and simulation analysis, greatly improving design efficiency and quality. On the other hand, virtual reality technology provides users with an immersive experience by constructing a three-dimensional virtual environment, making the design results more intuitive. When these two technologies are combined, designers can perform 3D modelling, material mapping, light and shadow rendering, and other operations on the product in a virtual environment, adjust design parameters in real-time, and observe the design effect. This fusion not only enhances the flexibility and visualization of design but also provides a broader space for the visual communication of products. With the increasing maturity of data collection, analysis, automatic generation, and output, various auxiliary design software helps to continuously improve visual communication design. In complex communication environments, channel fading is a common phenomenon that can lead to a decrease in signal transmission quality, thereby affecting the performance of the entire system. Li et al. [5] studied event-triggered sliding mode control of multi-agent systems under visual communication channel fading. When the channel quality is good, intelligent agents can frequently exchange information and collaborate in control. When the channel quality is poor, intelligent agents can cope with the impact of fading by reducing communication frequency or adopting visual communication strategies.

Computer-aided CAD designers utilize the computer itself and other related image processing equipment to assist designers in completing design-related tasks. Multi-agent systems (MAS) have been widely applied in various fields. As a distributed intelligent system, MAS achieves the decomposition and efficient execution of complex tasks through collaboration and interaction among multiple agents. Especially in the field of visual communication, automatically generated multi-agent system models demonstrate enormous potential and sustainable application value. In visual communication, the automatically generated multi-agent system model can achieve real-time information transmission, dynamic display, and intelligent processing. Through collaborative work between agents, the system can collect, integrate, and present various types of data in real time, providing decision-makers with intuitive and comprehensive information support. At the same time, the model can also automatically adjust communication strategies, optimize communication effectiveness, and improve user experience based on changes in data and user feedback [6]. CAD technology is also the preferred tool for art and visual communication designers in simulation production and image innovation. In response to the challenges in large-scale scenarios, Liu et al. [7] introduced the idea of a mean-field based on the PICO algorithm, approximating the distribution of observation information in large-scale testing scenarios to that in small-scale training scenarios. This enables the strategies obtained from small-scale scenario training to be applicable to large-scale testing environments. Simultaneously, using the large-scale reinforcement learning framework MAgent to optimize inference efficiency. Finally, the algorithm performance was verified through experiments to be stable even in large-scale testing scenarios. It trains and tests relevant algorithms in a two-dimensional gridded scene, and attempts to set various obstacle densities and number of intelligent agents. The experimental results show that the algorithm proposed in this paper outperforms other baseline methods in terms of performance indicators while ensuring lower collision rates and better scalability.

Sathiyaraj and Bharathi [8] discussed how to use multi-agent systems to construct an efficient intelligent traffic light visual communication system to effectively avoid traffic congestion. A multi-agent system consists of multiple intelligent agents with autonomous decision-making and collaborative capabilities, which can perceive traffic conditions in real time and optimize traffic flow through information sharing and collaborative decision-making. In traffic management, multi-agent systems can be applied to traffic light control, vehicle scheduling, path planning, and other aspects to improve traffic operation efficiency. The traditional visual communication design content includes graphics, text, colours, lines, etc. on the plane. By combining multiple elements, the conveyed information set can be accurately expressed, and the audience can also obtain psychological satisfaction from visual communication design works. Multimedia data transmission technology has become an important pillar in today's information age. It provides new possibilities for the dissemination and design of artistic visual information, making design works more vivid, rich, and efficient in conveying to the audience. Sun and Kwak discussed the design method of artistic visual information dissemination based on multimedia data transmission technology [9]. In the dissemination of artistic visual information, this technology can transform traditional static design works into dynamic interactive multimedia forms, thereby better attracting the attention of the audience and conveying design intentions. Specifically, through multimedia data transmission technology, designers can digitize the images, animations, audio, and other elements of their works, and publish and disseminate them through online platforms. Audiences can enjoy and interact with these works anytime and anywhere through the Internet or mobile devices. This new way of communication not only breaks the limitations of time and space but also greatly enriches the expression and connotation of artistic visual information.

With the continuous updates of information technology, visual communication design is compatible with more disciplines and fields and has continuously developed into a collaborative medium between various industries. In a broad sense, visual communication not only involves content such as text, videos, and multimedia on a flat surface but also includes modern immersive three-dimensional displays and other three-dimensional works. Nowadays, visual communication design involves animation and television communication design in four-dimensional space, where designers convey more diverse content to the audience. The receiver is not only a receiver of information but also a deliverer of visual experience. Symbols in visual communication can be transformed into language, directly penetrating into the recipient's soul. The special visual language makes the expressive power of text and patterns more abundant and prominent. Using visual design for language communication can make people more identify with the content of media information transmission. Therefore, the expression form of visual communication design needs to be updated and created in combination with the characteristics of the times. The optimization and strategic updates of this industry have also become important ways to promote the development of the field.

2 DEVELOPMENT STATUS OF CAD TECHNOLOGY AND MULTI-AGENT SYSTEMS

CAD technology, with its powerful 3D modelling and rendering capabilities, provides strong support for visual communication in mobile VR. Network visualization based on network tomography technology refers to the visualization of a large number of network performance features measured based on tomography technology in a graphical way. Therefore, utilizing knowledge from disciplines such as computer graphics and network topology to introduce visualization research into network tomography has become one of the application aspects of network tomography technology. In the network, the characteristics of latency are usually characterized by a random distribution, so inferring latency requires setting the system clock to be synchronized. And set a delay benchmark, first assuming the quantified discrete width variable value, and then using this value to perform equidistant segmentation of the delay. Sun et al. [10] used the average performance information in network tomography as prior information for Bayesian estimation. Infer performance parameters in the network under certain conditions. Bayesian estimation calculates the posterior distribution of the next posterior distribution by using the posterior distribution obtained from this prior information as the prior information for the next posterior distribution calculation, and then continuously iterates the calculation. Finally, a posterior distribution that is close to the true distribution will be obtained. Tian [11] used the search-based dynamic visual image frame of information transmission to explore the parameters with great care. For intelligent algorithms, research on heuristic search functions is crucial in multi-agent path planning. The simplest idea is to set the global heuristic function as the sum of the heuristic functions of all agents. Specifically, in simplified two-dimensional gridded scenes, Manhattan distance can be directly used as a heuristic function. Furthermore, there have been many studies and explorations in the design of global heuristic functions. However, experiments have shown that when the design of heuristic functions is too complex, the increase in computational overhead may actually reduce the overall execution efficiency of the system. In this regard, it is necessary to make trade-offs based on actual scenario requirements. Multi-agent systems will be one of the most important intelligent agent systems in the future. Training systems such as unmanned driving, robot swarms, and competitive sports are all applications of multi-agent systems. In multi-agent systems, collaboration is a very important way for agents to interact with each other. Among existing methods, communication-based multi-agent collaboration is the least computationally intensive and most effective approach. However, existing methods suffer from issues such as excessive communication volume and insufficient stability. In order to reduce the communication volume of intelligent agents, improve the overall stability of the system, and thereby improve the overall success rate of multi-agent collaboration systems, Wang et al. [12] proposed a set of multi-agent collaboration systems based on feature information communication. In this system, intelligent agents can communicate through the characterized information, thereby reducing communication volume and improving the overall efficiency of the system.

Wang and Yu [13] focused on the application of multi-agent reinforcement learning in multi-agent communication path planning. Based on certain communication mechanism exploration experiments, it innovatively proposes a dynamic communication topology mechanism based on priority guidance. And introduce it into the algorithm PICO in the communication-based multi-agent reinforcement learning framework. The priority is to learn from the planning results of the centralized planning algorithm ODrM * through imitation learning. The information dissemination path will be determined by these implicit priorities, and the obtained asymmetric information and different implicit constraints will encourage agents to plan almost collision-free paths. In addition to being beneficial for avoiding collisions, priority can also be further used to guide the establishment of dynamic communication protocols. In priority communication learning, the local priority output by the model is used to generate a time-varying communication topology composed of communication groups, where these priorities are considered as weights for self-organizing routing protocols. Each intelligent agent can learn its conflict reduction strategy through the received messages, which are actually perceptions of the environment and encoded by dynamic communication topologies. Inspired by priority design, Yang et al. [14] introduced implicit priority information into decentralized multi-agent reinforcement learning algorithms, and combined imitation learning to learn the optimal path planning strategy and implicit priority information of each agent in the system under decentralized settings from expert planners. In decentralized traditional path planning methods, priority information can select an intelligent agent to obtain the right to first pass or occupy the conflict location when a collision occurs. By training a neural network with supervised information to evaluate its global priority based on the current state, the policy can incorporate implicit priority information into its representation, ultimately enriching the learning signal of the policy and achieving better avoidance cooperation. Zhang and Kou [15] constructed a structured communication protocol with the ability to alleviate collision problems by integrating the learned implicit priority information into communication learning. This communication protocol combines the dynamic updating of the agent's implicit priority. Being able to adjust and reconstruct local communication groups in real time is more heuristic and instructive than end-to-end communication learning. To address the training difficulties in large-scale path planning scenarios, the mean-field approach is introduced to transform the observed state distribution information during testing into a state distribution that can be sampled during training. This ensures a more efficient training process and better generalization ability during testing.

Zhang et al. [16] used 3D virtual animation to replace real faces for real-time communication. The 3D virtual animation model is driven by user expressions. It will combine deep learning-based facial key point recognition and localization technology, virtual reality technology and instant messaging, and human-computer interaction with video chat to design and implement a highly interactive instant messaging system. Currently, video communication often faces problems such as latency and lag. Therefore, this project replaces video stream data with facial keypoint data for transmission, reducing network pressure. The project also uses speech encoding and decoding, noise reduction, echo cancellation and other processing methods to solve problems such as noise interference and echo interference in speech transmission. Zhao et al. [17] introduced a communication-based universal asynchronous multi-agent path planning framework. And verify the impact of the introduction and design of communication mechanisms on path-planning algorithms based on multi-agent reinforcement learning through experiments. It first analyzes the problems of multi-agent reinforcement learning algorithms based on a centralized training decentralized execution framework when solving multi-agent path planning problems. Then, communication learning was introduced to address this issue for improvement. Then, communication frameworks based on global channels and graph convolutional networks were introduced separately. And implemented three communication design ideas based on fully connected communication, local group communication, and graph convolutional network. Although using a centralized network can achieve good results, its drawbacks are high training costs and insufficient flexibility. If an intelligent agent is added to the network, the difference in the number of agents may lead to a significant difference in the final strategy. The training provided by this all-in-one network is very time-consuming because it requires training to obtain a global common strategy, and the search space is too large. If the intelligent agent can obtain information from other agents themselves and use this information as part of the agent's observation, then there is no need to maintain a global function. Zhou et al. [18] excluded less useful information by adding some filtering functions to the intelligent agent. However, the communication volume and frequency in the system are still very large, and as the number of intelligent agents increases, the increased communication volume will grow exponentially. If the intelligent agent can determine the receiver before sending information, it will reduce the communication volume of the entire system and increase its efficiency. Secondly, multi-agent systems can optimize coding strategies through collaborative learning. During the encoding process, each agent can continuously adjust and optimize encoding parameters based on its own processing results and feedback information from other agents, in order to achieve the global optimal encoding effect.

Visual communication design products require the use of virtual reality space in subsequent displays to highlight the intricacies of the design. As a distributed network environment, multi-agent systems can use network structure diagrams to combine coupled intelligent agents. In recent years, multi-agent systems have been widely used in fields such as drones, artificial intelligence, and virtual reality. The speed of multi-agent structure in handling intelligent agent classification and multi-layer system relationships has received unanimous praise. Related research experts believe that multi-agent systems can analyze the sensitivity of component systems in the context of the Internet of Things, and can also improve simulation performance in virtual reality environments. The simulation generation and sensitivity of the system are the main evaluation criteria, and dynamic equations are used as the computational basis for multi-agent systems without affecting many factors. In summary, CAD computer-aided technology can not only help optimize design parameters for art and design but also provide references for innovative strategies in visual communication design. The virtual reality enhancement technology of multi-agent systems can better present the actual effects of visual communication design works.

3 RESEARCH ON OPTIMIZATION STRATEGIES FOR VISUAL COMMUNICATION DESIGN BASED ON CAD TECHNOLOGY AND MULTI-AGENT SYSTEMS

3.1 Research on Visual Communication Design Optimization Based on CAD Computer-Aided Technology

With the rapid development of Internet technology, visual communication design has gained new opportunities and challenges. This reform of new media has shifted the transmission of information from vertical and horizontal to networked. Not only has it achieved technological extensions at different levels, but it has also promoted interdisciplinary development in the information transmission industry. Visual art expression and communication design have undergone new changes in the digital media era, breaking the limitations of traditional information dissemination and providing more flexible and free innovation opportunities for design professionals. Visual communication design is the process of information transmission, which combines the needs of the transmission target for reasonable classification and induction, thus forming a combination of elements, such as text, images, videos, colours, etc., in different dimensions. In addition, the design concept of visual communication also emphasizes the use of various visual methods for representation. In the context of technological progress, the diversified and innovative development of media has made computer and network technology new tools in design. We conduct a statistical analysis of the computer network update process of visual communication design from the perspective of the development process of the times and compare the development speed of different countries.

As shown in Figure 1, with the advent of the computer age, the updated understanding of visual communication design optimization in various countries has gradually increased. Visual communication design, with the United States as the main developing country, has been able to mature and combine with computer network-related technologies, gradually forming new design schools. The implementation process of visual communication design is relatively direct, which is more direct and vivid compared to text and images, allowing the receiver to perceive the design content from a spiritual level. The ultimate goal of this study is also to convey precise and special information to the public in order better to achieve the expression and circulation of modern data information. The role of visual elements in design is very obvious, and with the assistance of CAD technology, visual elements are more in line with aesthetic and application needs after adjusting detailed parameters. Traditional media visual communication only relies on content such as the internet, mobile phones, and big data to adjust works, while computer-aided CAD technology provides reliable assistance for processing large amounts of information data.

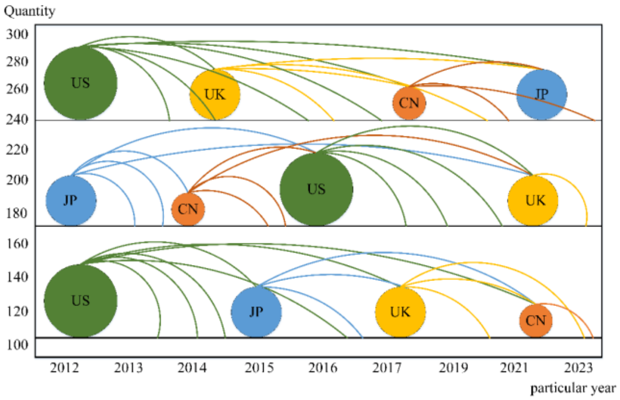

Figure 1: The evolution process of visual communication design.

In this study, CAD computer-aided technology is used to optimize visual communication design strategies. Firstly, the interdisciplinary integration of visual elements is studied to make design works more in line with modern people's living habits. Different visual communication content has different communication needs; some focus on content presentation methods, while others emphasize the interactivity between visual works and users. So, in the automated design system formed by CAD technology, we should take targeted measures to match visual elements to the unique preferences and needs of the audience. Due to the various ways of representing visual communication design, we focus on the animation production effect of visual communication design in our research. The traditional process of hand-drawn animation is essentially the creation and production of sequential combinations of graphics and text. Digital processing is the process of converting multiple complex image contents into adjustable digital parameters, establishing design models based on parameter data, converting them into binary codes, and ultimately outputting visual works. However, traditional two-dimensional visual communication design is susceptible to the influence of curves and data from different planes in the construction of digital models and the generation of static initial images. At the same time, in the process of generating 2D animation, the current visual processing methods may also have problems, such as poor animation presentation and poor quality. To this end, we introduce computer-aided design CAD technology to optimize visual communication design strategies and form a three-dimensional animation space. The three-dimensional visual communication design works are not limited by elements such as time and space and adopt different forms of expression to express vivid three-dimensional visual works abstractly. The logic of 3D visual communication design optimized by CAD technology is shown in Figure 2.

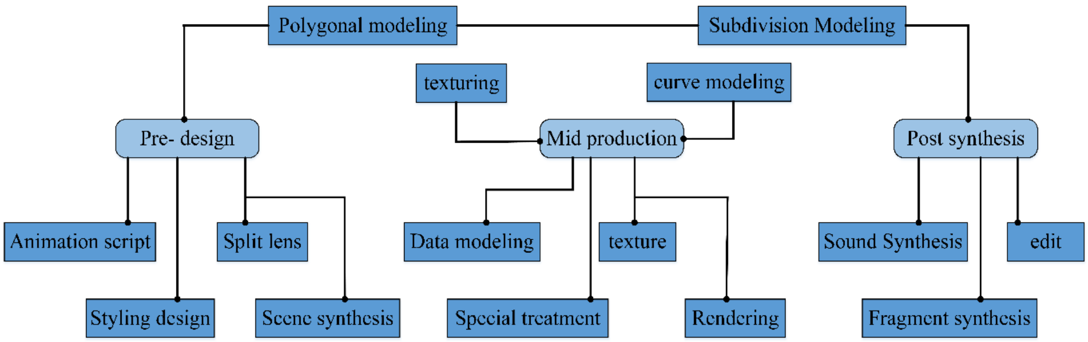

Figure 2: CAD technology optimized three-dimensional visual communication design logic diagram.

As shown in Figure 2, the visual communication design strategy optimized by CAD technology adjusts design thinking in three stages: front, middle, and back. In the early stage, the design ideas were refined to include script and shot separation. In the middle stage, three-dimensional animation effects were achieved by combining polygonal and curve modelling. In the later stage, multimedia content such as audio and video were added to generate visual communication animation files. The optimized visual communication design logic utilizes interdisciplinary knowledge such as computer science, simulation, and art, with computer-aided design technology as the core foundation, fully integrating visual elements. Deeply understanding the optimization strategies for visual communication design, the multi-visual presentation automation model generated using CAD technology is improved based on changes in keyframe images. Refer to the influence of discrete data and raw spatial sampling on the depth and color of animation presentation, and determine whether the calculation formula of the visual communication 3D design model is effective. Describe the relationship between the capture position of the visual camera and the objective function in the design:

$$A\left(\frac{|w_{ji}|}{a^{ji}}, a^T\right) \tag{1}$$

In the formula, A representing the visual projection error coefficient, estimate and calculate based on the standard deviation of internal feature points of multiple keyframes in animation design:

$$A_i(t)[ji] = u_i(t) \tag{2}$$

The overall correction animation model performs collaborative processing on the original generated image using the following formula:

$$(t_1, t_2, ..., t_n) \ = \arg\max \sum_{i=1}^{n} A \tag{3}$$

$$Y_1, Y_2, ..., Y_n \ = \arg\min \sum_{i=1}^{N} A\left(\frac{|w_{ji}|}{a_{ji}}, a^T\right) \tag{4}$$

In the formula, w_{ji}, a_{ji} representing multiple machine parameters captured in visual communication animations, as well as the feature relationship between automated description vectors and spatial scenes. Assuming that the image scheme of CAD visual communication design animation has fixed depth and smoothness, the following formula can describe the model of calculation functions such as animation depth:

$$w_d = \int_u (w_{da} y_i + \delta w_e) d\varepsilon \tag{5}$$

In the formula, w_d Describe the evaluation score of visual images and optimize the formula based on weight coefficients and depth range:

$$w_{da} = \frac{1}{|E(R)|} \sum_{i=1}^{N} |E_r y_r - \varepsilon'| \tag{6}$$

Compare the data information between keyframes and image sequences in each keyframe at each moment to obtain the pixel coordinates generated by visual design optimization. The calculation formula is as follows:

$$\varepsilon' = \tau^{-1}[LR_r^i \alpha(\varepsilon, d)] \tag{7}$$

$$W_{re} = f(b) \,||\, \nabla d(b) \,|| \tag{8}$$

The above formula includes the statistics of animation presentation parameters and pixel coordinates for visual communication design optimization systems. Next, we will describe the depth pixel gradient weights within the design system and associate them with the centre coordinates of multiple planes. To accurately obtain the auxiliary variables, we will use the following formula:

$$W_d = \int [f(b) \mid \nabla d \mid + \frac{1}{2\theta}(d-m)^2] \tag{9}$$

$$W_m = \int [\frac{\varepsilon}{E(r)} \sum_{i=0}^{n} \mid E_i(\varepsilon) - E_r(\varepsilon, m) \mid] d \tag{10}$$

In the formula, ε represents a depth pixel constant. Compared to other calculation processes, after introducing relevant feature points, it can automatically convert the animation presentation effect into the optimal parameter ratio, providing a foundation for texture design, colour matching, scene rendering, and other visual communication of 3D models in the later stage. Creativity and aesthetics are the focus of visual communication design optimization. In the process of information content transmission, optimizing the human-computer interaction effect and letting the public experience the connotation of artistic creation are the focus of designers. More and more visual communication design works are being combined with technologies such as computers and virtual reality, using advanced editing tools to present visual elements while allowing visual elements to be displayed in the effect of feature amplification. Due to the diverse composition of visual elements, we will use multi-agent systems to reconstruct the optimized visual communication design scene effect in the future.

3.2 Research on Visual Communication Design Optimization and Virtual Reality Display Based on Multi-Agent Systems

Visual communication design can disseminate design works in a specified way, which is a subjective behaviour of conveying reliable parameter data information to recipients through visual media. Essentially, visual communication design is the process of real-time visual data transmission, and its potential value also depends on the quality of information presentation and the accuracy and reliability of presentation speed. In our research, we utilized multi-agent systems to optimize virtual reality scenes and achieve better 3D image rendering. The simulation animation, virtual scene interaction process, and finished product display system are shown in Figure 3:

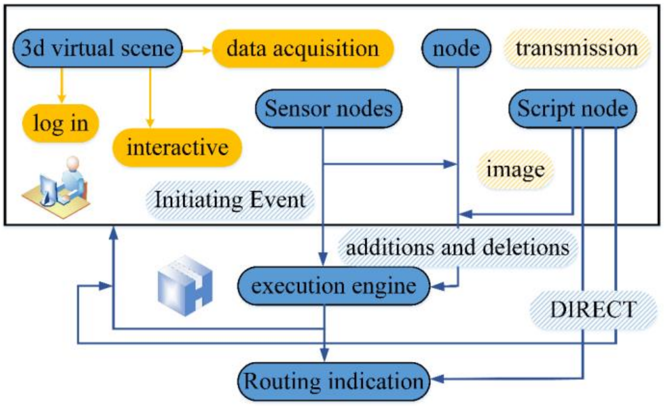

Figure 3: Simulation animation virtual scene interaction process.

As shown in Figure 3, the 3D visual communication design animation simulation scene includes sensors, scripts, events, and other content. The transformation and communication of requirement attributes are achieved through the input and output of information and data. Sensor nodes can also help virtual scenes perceive user needs, judge the interaction process of visual communication design in virtual space, and adjust the scene rendering progress based on node interfaces. Multi-agent system simulation platforms are specialized in building experiments for application fields and are representative and authoritative. We utilize multi-agent systems to optimize traditional virtual space scenes and look forward to showcasing better 3D visual communication design works. Before establishing a virtual simulation platform for multi-agent systems, we study the behavioural relationships of agent feature objects and model three-dimensional visual element objects. The framework diagram of the visual communication design simulation platform for multi-agent system optimization is as follows:

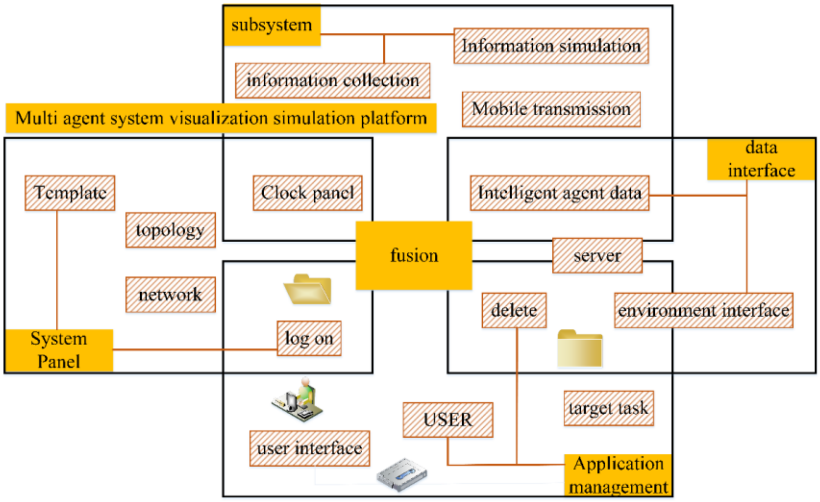

Figure 4: Framework diagram of visual communication design simulation platform for multi-agent system optimization.

As shown in Figure 4, multi-agent systems are committed to achieving visual simulation scenarios, incorporating data movement and media dissemination processes into the internal structure of the system. By managing the simulation environment, user data, and target works, utilizing the feedback mechanism of intelligent agents, the scene construction effect is transmitted to the main control terminal. The animation model rendering process for the three-dimensional visual communication design of multi-agent systems needs to consider coordinate changes such as internal texture, colour, and pattern matching. The rendering mapping formula is used to describe it as follows:

$$r(x_z, y_z) = \phi(h(u, z)) \tag{11}$$

In the formula, x_z、y_z map data packets representing three-dimensional visual communication design works. Analyze the rendering information that can be obtained from model pixels and resolution, and use multi-agent system input data to obtain corresponding coordinates:

$$y_0 = [x_0, y_0, 1], H_0 = [h_0, h_0, 1] \tag{12}$$

$$\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} h_x, 0, 0 \\ 0, h_y, 0 \\ 0, 0, 1 \end{bmatrix} \begin{bmatrix} x_0 \\ y_0 \\ 1 \end{bmatrix} \tag{13}$$

The above formula can transform the input visual communication design animation parameters into the data information required for rendering. By using the bilinear calculation formula, the spatial coordinate difference between adjacent design images can be obtained:

$$p(x, 0) = x[p(1, 0)], p(x, 1) = x[p(1, 1)] \tag{14}$$

$$p(x,y) = y[p(x,1)] \tag{15}$$

By integrating the above formulas, the element difference between the input and output points of the 3D visual communication model can be obtained, and the rendering depth of the virtual reality scene can be automatically adjusted based on the range of visual element differences. According to research, multi-agent systems are complex tasks that achieve collaborative strategy adjustment through large-scale simple data layouts. Therefore, the number of objects designed in visual communication design optimization will have a certain impact on the final scene display. The intelligent agent system completes data coordination and iteration through internal strategy adjustments, ultimately achieving a virtual reality display of visual communication design works.

4 ANALYSIS OF RESEARCH RESULTS ON OPTIMIZATION STRATEGIES FOR VISUAL COMMUNICATION DESIGN BASED ON CAD TECHNOLOGY AND MULTI-AGENT SYSTEMS

4.1 Analysis of Research Results on Visual Communication Design Optimization Based on CAD Computer-Aided Technology

Traditional visual communication design thinking only focuses on the combination and processing of points, lines, surfaces, text, patterns, and other content on a two-dimensional plane. Modern information has brought new requirements to communication media, which forces visual communication design to make strategic adjustments and optimizations. CAD technology can quickly complete the effect changes of art and design through its internal system while also combining complex visual elements to improve the expression of design works. Computer-aided design helps to integrate visual communication with multiple disciplines, thus achieving expressive three-dimensional displays. In our research, we mainly explore the display of animated works in visual communication design, use CAD technology to build three-dimensional digital models, and construct virtual reality scenes. Allowing animated characters to freely transform in visual scenes without constraints of time and space, improving the fluency of visual communication design works in the display. During the experiment, we also need to pay attention to the changes in the coordinates of the body structure elements of the animated characters. The character characters are constructed based on the relationship between the human body structure, and the position table of the animation character's body joints is reshaped based on the key points of the bones:

Joint Name	*X*	*Y*	*Long*	*Wide*
Left Arm	78	223.5	16	68
Right Arm	75	288.9	10	65
The Left Hand	70	350.2	11	29
The Right Hand	71	450.6	12	30
Left Leg	53	320.2	30	98
Right Leg	54	271.9	29	95
Spine	13	140.6	17	24

Table 1: Animation Character Body Joint Positions.

From Table 1, it can be seen that when calculating the possible joint positions of animated characters, we place the statistical centre of gravity on each major joint node of the limbs and design the size of the character through the positioning of three-dimensional spatial coordinates. In order to verify the visual communication design effect optimized by CAD technology studied in this article, we selected multiple movement angles in animation production to compare the clarity of the generated images, as shown in Figure 5:

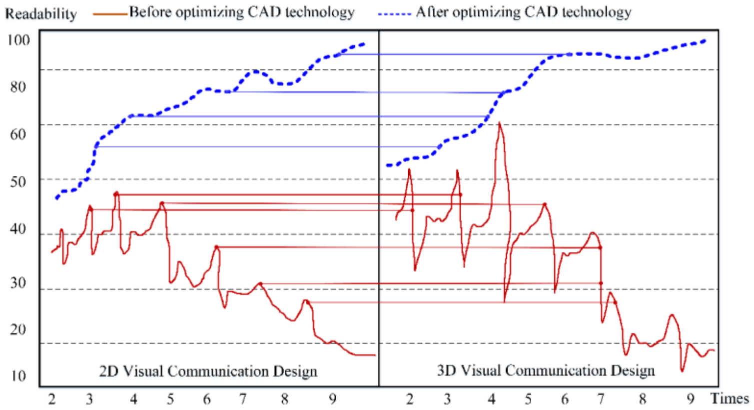

Figure 5: Comparison of the clarity of generated images.

From Figure 5, it can be seen that in image selection, we take two-dimensional visual communication design works and three-dimensional visual communication design works as examples, and compare the visual communication design content before and after CAD technology optimization. It has been found that CAD technology can accurately improve the clarity of images. At the same time, we will present the feature point-matching results of the test object.

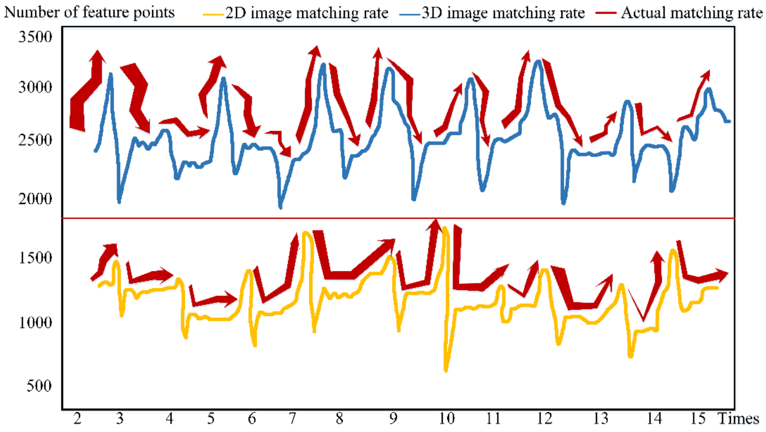

Figure 6: Matching results of feature points of test objects.

From Figure 6, it can be seen that the matching of the number of feature points of the two test objects is quite consistent, which further indicates that using CAD technology for visual communication design in 3D animation modelling can improve the feature matching rate of design elements to over 80%. The matching effect of feature points can directly affect the accuracy of visual communication design modelling, and the relationship between the two is inseparable. Therefore, with the help of CAD technology, visual communication design can achieve advantages in space and scene transformation. In the future, we will also conduct result analysis on the scene display of visual communication design works during the final generation, further exploring the actual effects of design optimization.

4.2 Analysis of Research Results on Virtual Reality Display Based on Visual Communication Design Optimization of Multi-Agent Systems

Visual communication design mainly utilizes visual elements to display information and data, facilitating people to quickly analyze and obtain the connotation represented by visual communication works. Among numerous visual elements, textual and visual elements are the focus of original visual design. Due to the increasing impact of modern information technology on digital media, visual communication design works are also beginning to integrate with virtual reality scenes. More visual communication designs are focused on virtual interactive effects in three-dimensional space in the final scene display, which brings impactful changes to the experience and perception of the masses. We use multi-agent systems to complete the physical display of visual communication design in our research, optimize the network virtual structure, and rebuild the virtual animation model using this technology. Combine the visual communication data generated by multi-agent systems and CAD technology, and use the data source as input to adjust the scene rendering effect. This experiment uses two computer clients as monitoring sources for scene construction and achieves the storage of three-dimensional database resources through data scheduling on different hosts. The performance indicators of ordinary virtual reality systems are mainly reflected in system computation, scheduling time, and corresponding interaction time with users. The system pays little attention to the single-frame image generation speed of visual communication design during operation. After constructing a virtual scene using a multi-agent system, we compared the image generation rates of the two scenarios, as shown in Figure 7.

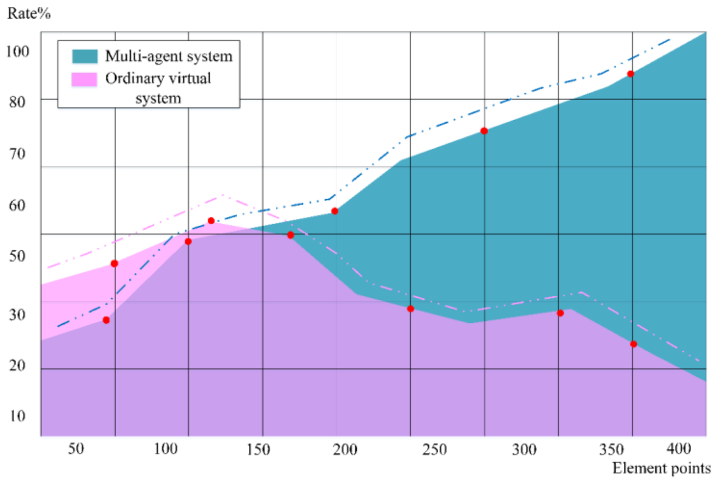

Figure 7: Comparison of image generation rates between two scenarios.

As shown in Figure 7, based on the changes in element points of the image data, it can be seen that the virtual scene built by the multi-agent system has a significantly faster speed in generating visual communication design works compared to ordinary virtual systems. At the same time, the rendering effects of the generated visual communication design 3D animations are also more diverse and colourful, including not only temporal frame rate changes but also the automatic addition of four-dimensional elements such as audio and video. From this, it can be seen that multi-agent systems have high feedback generation efficiency and rendering effect in network virtual scene construction. Its internal subtask decomposition and scheduling can reduce system consumption, thereby completing the processing requirements of a large amount of visual design data. According to the research results, it can also be concluded that the optimization strategy of visual communication design tends to be more dynamic and multi-dimensional. Compared to traditional two-dimensional visual works, dynamic and multi-dimensional visual communication design is more interactive, and this feature is more prominent in virtual reality scenes.

5 CONCLUSIONS

Traditional visual communication design emphasizes the integration of comprehensive disciplines while also meeting the needs of the public for media information acquisition. This creates new requirements and innovative tasks for visual communication design works in two-dimensional space in the digital media era. With the increasing effectiveness of applications such as computers, information technology, and virtual reality technology, various computer-aided design works are also beginning to play their unique value. Starting from CAD computer-aided design technology, this article explores the strategic changes in optimizing visual communication design and combines multi-agent systems to innovate the final scene presented in visual communication design works. Firstly, analyze and judge the various impacts involved in the optimization process of visual communication design, with visual communication animation as the main research object. Using CAD technology to solve the problem of poor continuity in generating visual communication design animations and constructing a three-dimensional mathematical model. Establish a variable and adjustable animation parameter system to automatically update keyframes created by computer-aided design. Secondly, with the help of CAD technology and multi-agent systems, virtual reality 3D rendering and display of visual communication design works are completed. Rebuilding a three-dimensional virtual space to enhance the speed of generating visual communication design works, making animation resolution and pixel information clearer. Finally, an analysis of the optimization effects of CAD technology and multi-agent systems is conducted to explore the application value of these two tools in visual communication design optimization strategies. The research results indicate that CAD computer-aided technology and multi-agent systems can provide new innovative strategic ideas for visual communication design, and are more in line with the preferences of the public in practical scenarios.

Min Zhang, https://orcid.org/0009-0006-6382-4359

REFERENCES

[1] Azeroual, M.; Lamhamdi, T.; El Moussaoui, H.; Markhi, H.: Simulation tools for a smart grid and energy management for microgrid with wind power using multi-agent system, Wind Engineering, 44(6), 2020, 661-672. https://doi.org/10.1177/0309524X19862755

[2] Bao, D.-W.; Yan, X.; Xie, Y.-M.: Encoding topological optimisation logical structure rules into multi-agent system for architectural design and robotic fabrication, International Journal of Architectural Computing, 20(1), 2022, 7-17. https://doi.org/10.1177/14780771221082257

[3] Dev, K.; Maddikunta, P.-K.-R.; Gadekallu, T.-R.; Bhattacharya, S.; Hegde, P.; Singh, S.: Energy optimization for green communication in IoT using Harris Hawks optimization, IEEE Transactions on Green Communications and Networking, 6(2), 2022, 685-694. https://doi.org/10.1109/TGCN.2022.3143991

[4] Guo, Q.; Ma, G.: Exploration of human-computer interaction system for product design in virtual reality environment based on computer-aided technology, Computer-Aided Design & Applications, 19(S5), 2022, 87-98. https://doi.org/10.14733/cadaps.2022.S5.87-98

[5] Li, W.; Niu, Y.; Cao, Z.: Event-triggered sliding mode control for multi-agent systems subject to channel fading, International Journal of Systems Science, 53(6), 2022, 1233-1244. https://doi.org/10.1080/00207721.2021.1995527
[6] Liang, Z.; Várady, G.; Zagorácz, M.-B.: Sustainable application of automatically generated multi-agent system model in urban renewal, Sustainability, 15(9), 2023, 7308. https://doi.org/10.3390/su15097308
[7] Liu, Q.; Chen, C.; Chen, S.: Key technology of intelligentized welding manufacturing and systems based on the internet of things and multi-agent, Journal of Manufacturing and Materials Processing, 6(6), 2022, 135. https://doi.org/10.3390/jmmp6060135
[8] Sathiyaraj, R.; Bharathi, A.: An efficient intelligent traffic light control and deviation system for traffic congestion avoidance using multi-agent system, Transport, 35(3), 2020, 327-335. https://doi.org/10.3846/transport.2019.11115
[9] Sun, L.; Kwak, N.: Visual communication design method in folk art based on multimedia data transmission technology, International Journal of Information Systems and Supply Chain Management (IJISSCM), 17(1), 2024, 1-19. https://doi.org/10.4018/IJISSCM.338383
[10] Sun, Y.; Chen, Z.; Tao, M.; Liu, H.: Communications, caching, and computing for mobile virtual reality: Modeling and tradeoff, IEEE Transactions on Communications, 67(11), 2019, 7573-7586. https://doi.org/10.1109/TCOMM.2019.2920594
[11] Tian, Z.: Dynamic visual communication image framing of graphic design in a virtual reality environment, IEEE Access, 8(1), 2020, 211091-211103. https://doi.org/10.1109/ACCESS.2020.3022644
[12] Wang, Q.; Hu, J.; Wu, Y.; Zhao, Y.: Output synchronization of wide-area heterogeneous multi-agent systems over intermittent clustered networks, Information Sciences, 619(1), 2023, 263-275. https://doi.org/10.1016/j.ins.2022.11.035
[13] Wang, Q.; Yu, Z.: Deep learning-based scene processing and optimization for virtual reality classroom environments: A study, Traitement Du Signal, 41(1), 2024, 115-125. https://doi.org/10.18280/ts.410109
[14] Yang, R.; Liu, L.; Feng, G.: An overview of recent advances in distributed coordination of multi-agent systems, Unmanned Systems, 10(03), 2022, 307-325. https://doi.org/10.1142/S2301385021500199
[15] Zhang, G.; Kou, X.: Research and implementation of digital 3D panoramic visual communication technology based on virtual reality, International Journal of Communication Systems, 35(5), 2022, e4802. https://doi.org/10.1002/dac.4802
[16] Zhang, H.; Wang, J.; Li, Z.; Li, J.: Design and implementation of two immersive audio and video communication systems based on virtual reality, Electronics, 12(5), 2023, 1134. https://doi.org/10.3390/electronics12051134
[17] Zhao, Y.; Ge, L.; Xie, H.; Bai, G.; Zhang, Z.; Wei, Q.; Zhou, F.: ASTF: visual abstractions of time-varying patterns in radio signals, IEEE Transactions on Visualization and Computer Graphics, 29(1), 2022, 214-224. https://doi.org/10.1109/TVCG.2022.3209469
[18] Zhou, Y.; Tian, L.; Zhu, C.; Jin, X.; Sun, Y.: Video coding optimization for virtual reality 360-degree source, IEEE Journal of Selected Topics in Signal Processing, 14(1), 2019, 118-129. https://doi.org/10.1109/JSTSP.2019.2957952