Synergistic Optimization of CAD and Virtual Reality Technology in Visual Communication and Information Visualization Design

Xiangjin Zhu[1], Jinyin Peng[2], Wei Bi[3], Fangyu Xiang[4] and Chaoqiao Yang[5]

[1]Design School, Hainan Vocational University of Science and Technology, Haikou, Hainan 571126, China, zhuxiangjin0528@126.com
[2]School of Mechanical and Electrical Engineering, Hainan Vocational University of Science and Technology, Haikou, Hainan 571126, China, zhuxiangjin@hvust.edu.cn
[3]Guangdong University of Finance & Economics, Guangzhou, Guangdong 510000, China, 20191077@gdufe.edu.cn
[4]Dhurakij Pundit University, Bangkok 10210, Thailand, qq412326148@gmail.com
[5]Dhurakij Pundit University, Bangkok 10210, Thailand, chaoqiao.yan@dpu.ac.th

Corresponding author: Jinyin Peng, zhuxiangjin@hvust.edu.cn

Abstract. This paper addresses the issues of poor information transmission and low efficiency in the process of visual communication and information visualization design. By analyzing the characteristics and advantages of CAD and virtual reality technology and considering their current application status in the design field, this paper proposes a collaborative optimization strategy for CAD and virtual reality technology in visual communication and information visualization design. The paper discusses the collaborative application of the two from theory, practice, and design practice. This paper aims to explore a more scientific, reasonable, efficient, and convenient collaborative optimization method for visual communication and information visualization design so as further to promote their wide application in the design field.

Keywords: CAD Technology; Virtual Reality Technology; Visual Communication; Information Visualization; Collaborative Optimization.
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1 INTRODUCTION

With the rapid development of information technology and the widespread use of smart devices, more and more design application scenarios are transitioning from two-dimensional (2D) to three-dimensional (3D) space. The field of visual communication design is no longer limited to 2D space but is expanding towards 3D, 4D, and even higher dimensions. Bishoyi and Misra [1] delved into a body-to-body network (BBN) framework. The core of its research lies in designing a novel signal distribution allocation mechanism aimed at motivating all participating WBAN users to actively collaborate, share, and upload their data to each other. In order to support the efficient operation of this mechanism, they further developed a distributed algorithm. Combined with visual communication technology, its framework can provide users with intuitive network status displays and data analysis tools. This framework not only enables nearby wireless body area network (WBAN) users to collaborate and share network resources, thereby improving overall network performance but also combines visual communication technology to provide users with a more intuitive and efficient network experience. Theoretical analysis shows that their proposed distributed algorithm can converge to a solution that maximizes the overall benefits of users. Users can view the real-time allocation of network resources, data upload progress, and auction results through a visual interface, making network management and optimization more convenient.

On the one hand, a large amount of information required for design activities is visually displayed through graphics and images, allowing the audience to receive the information conveyed by the designer directly through visual perception. In real-world engineering design, complex systems are typically composed of multiple components with interdependent relationships. Chen and Fuge [2] introduced a new approach that utilizes generative models learned from examples to synthesize these hierarchical designs. The interaction between these models is based on part dependency diagrams, ensuring that when a component's design changes, other related components can also make corresponding adjustments. This framework allows us to conditionally generate or explore the design of each component based on known dependencies. This graph-based interaction mechanism enables our method to handle complex dependency networks rather than just simple linear or tree structures. On the other hand, insufficient consideration of details during the design process results in omissions or errors in the information received by the audience, which affects the visual communication effect. Therefore, it is particularly important to introduce CAD (Computer Aided Design, CAD) and virtual reality (Virtual Reality, VR) technology into the process of visual communication and information visualization design to solve this problem. Potential factor models (LFM) based on collaborative filtering (CF), such as matrix factorization (MF) and deep CF methods, have been widely integrated into modern recommendation systems (RS) due to their excellent performance and recommendation accuracy. Deldjoo et al. [3] introduced the latest research trends in adversarial machine learning (AML) in the field of recommendation system security. It demonstrates another successful application of Adversarial Generative Networks (GANs) in AML, thanks to their powerful ability to learn complex (high-dimensional) data distributions.

In addition, CAD and virtual reality technology not only have good intuition, high efficiency, and low cost but also can improve the quality and efficiency of design. Moreover, there is a synergistic effect between them, and their effective combination can achieve a 1+1>2 effect. By improving existing computer graphics and image processing techniques, designers can further stimulate their innovative thinking and enhance their creative abilities. In this process, Fan and Li [4] analyzed in detail the theoretical frameworks of cognitive psychology and semiotics closely related to computer graphic visual communication. It reveals the core mechanism of graphic information in information transmission. Computer graphics are not only an efficient way of information transmission but also play a crucial role in interface design, especially in mobile media. They focus on information research in the field of graphic visual communication, delving into the uniqueness of graphic information and its important role in visual communication. This prediction not only highlights the value of graphics technology in modern communication but also indicates that the communication mode that integrates information and graphics will have broader application prospects and greater development potential in the future. Franconeri et al. [5] reviewed the guidelines supported by research to create effective and intuitive visualizations and communicate data to students, colleagues, and the public. It extracts global statistical information quickly but compares slowly between subsets of values. Effective graphics can avoid wasting working memory, guide attention, and respect familiar conventions. Effectively designed data visualization enables viewers to use its powerful visual system to understand data patterns in science, education, health, and public policy. Designing ineffective visualizations can lead to confusion, misunderstandings, and even distrust, especially among audiences with lower graphic literacy. Data visualization can play a crucial role in teaching and communication, provided that designers customize these visualizations according to the audience. They described how the visual system quickly extracts extensive statistical data from displays, and poorly designed displays can lead to misunderstandings and hallucinations. Based on this, this article will analyze the current application status of both in the field of visual communication and information visualization design and explore specific strategies and optimization directions for their collaborative application.

2 RELATED WORKS

Under the background of the continuous development of computer technology, visual communication and information visualization design have undergone a transformation from traditional two-dimensional plane design to three-dimensional design and have been gradually accepted and recognized by designers in practice, becoming an important branch in the field of modern design. Foreign scholars have conducted extensive research on the application of computer-aided design (CAD) and virtual reality technology (VR) in the field of design. For example, some scholars have proposed a method for designing architectural information models based on CAD and VR by studying the relationship between architectural information models and CAD. Some scholars have also proposed a method for designing information models based on CAD and VR to improve interactivity and transmission efficiency by using highly error-tolerant models to address the problem of low information error rates in the process of visual communication. Domestic scholars' research in this area mainly focuses on theory. In visual-based structural health monitoring (SHM), the application of deep learning (DL) to evaluate structural damage has become a popular trend. To address these issues, Gao et al. [6] proposed an innovative approach called Balanced Semi-Supervised Generative Adversarial Network (BSS-GAN). Under the condition of limited computing power, it conducted a series of computer experiments on the classification of concrete cracks and peeling. The excellent performance of BSS-GAN is not only attributed to its unique learning framework but also to its powerful ability to deal with low data imbalance problems. The experimental results show that compared with other traditional methods, BSS-GAN exhibits better performance in key indicators such as recall and accuracy. In visual information communication design, the product design method of "mainly using two-dimensional planes and supplemented by three-dimensional models" cannot maximize the intuitive effect of three-dimensional information modelling, thus affecting the efficiency of design. To address these issues, Gu et al. [7] proposed the establishment of an artificial intelligence-based visual information communication system. The experimental results show that the maximum distortion of the designed system is about 15%, while the maximum distortion of traditional samples is 20%. With the continuous development of Internet of Things technology, various sensing devices can be used to achieve information exchange between people and things and to establish innovative modern art. Through this method, image information can be made clearer and have a larger field of view and magnification. Compared with traditional samples, this system has significant advantages in graphic conversion. In addition, the colour difference of the optical system can be corrected to improve the imaging effect.

Hu et al. [8] provide an interactive visual communication user interface that supports communication-based fluid design through a perceptual understanding of human sketches. Its network communication model is trained using hand-drawn strokes and corresponding two-dimensional velocity fields. Based on the generated velocity field, the system uses the semi-Lagrangian method to calculate fluid dynamics. They conducted user research on the proposed system and confirmed that the proposed interface is effective for 2D fluid design, and the system achieved good results based on user input. The proposed system utilizes conditional generative adversarial network models to generate stationary velocity fields from sketch inputs. Specifically, the proposed system generates 2D fluid animations from hand-drawn sketches. Many educators in various disciplines are attempting to integrate this technology into their teaching processes, with the aim of creating an interactive learning environment for students to enhance their interest in learning. Visual communication design focuses on conveying information and emotions through visual elements, and VR technology can help students understand and master visual language more intuitively. In this study, Jiawei and Mokmin [9] focused on students from art colleges to explore the development trend of using VR technology for immersive learning in art and design education. The results indicate that there are currently no practitioners using fully immersive VR technology in the art teaching of visual communication design. The virtual reality technology with immersive learning capabilities has been highly tested and developed and can be used by students in art and other subjects, achieving positive results.

In the era of network-based social networks, visual communication plays an important role in business and public communication. Kujur and Singh [10] proposed a theoretical model on how visual communication through consumer engagement on corporate social media pages affects consumer-brand relationships. High-quality visual effects have increased the visibility of social networking sites and have been selected as a key activity for the organization. Visual communication plays a crucial role in engaging behaviour on social media, further increasing sales. Social networks, with their sharp features, can attract numerous users to interact with others. The use and satisfaction theory has been used to study the behavioural responses of consumers to consumer participation in social media environments. The structural equation model has been used and validated to examine the impact of visual effects with informative, entertaining, and rewarding content on consumer engagement, further leading to a relationship between consumers and brands. Video denoising plays a crucial role in outdoor visual systems, especially in visual communication, where clear and noise-free video quality is crucial for information transmission. Mu et al. [11] developed an innovative model-guided three-level optimization framework that combines the needs of visual communication, aiming to improve video denoising performance, especially in various rainfall situations. In order to overcome the problem that existing methods cannot fully cover various rainband distributions, they designed an optimization model for task variables and hyperparameters. This collaborative work approach enables the network to utilize resources and improve denoising performance more effectively. This scheme combines the Optical Flow Module (OFM) and Time Grouping Module (TGM) to help recover potential frames and improve video clarity and coherence by searching and optimizing the combination of these modules. This model enables the denoising network to better adapt to video data under different rainfall conditions through fine adjustment of parameters.

Data visualization plays a crucial role in human-computer interaction interface design. It is not only a bridge for information transmission but also a key factor in optimizing user experience. In order to further improve the effectiveness of data visualization, Rui et al. [12] designed an analysis method based on EEG signals. From the perspective of visual communication, it is found that data visualization is not only the presentation of data but also a way of communication. Meanwhile, visual communication can also stimulate user interest and curiosity, enhancing the emotional connection between users and data. This indicates that aesthetic factors and user experience are equally important in data visualization interface design. It needs to comprehensively consider the subjective feelings and objective evaluations of users and continuously optimize the design of data visualization interfaces. Through carefully designed data visualization interfaces, complex data and information can be effectively transformed into intuitive and easily understandable graphics and images. With the deep integration of mobile communication and edge computing, wireless networks are facing increasing pressure to access heterogeneous tasks, which compete for computing and communication resources at the edge. In heterogeneous task scenarios, multiple end devices (ED) need to collaborate with each other to complete complex tasks. To optimize this process, Xu et al. [13] proposed a task completion time minimization problem. It is intended to jointly optimize edge task partitioning, compute resource type matching, and allocation. Combining visual communication technology, they proposed a DT-driven edge collaborative scheduling algorithm to manage better and optimize heterogeneous tasks and computing/communication resources. Combined with visual communication technology, their scheduling algorithm can provide users with intuitive and easy-to-understand network status and task progress display. Through a visual interface, users can view real-time load conditions, task partitioning and allocation results, transmission power control, and other information about ED and ES.

Yang et al. [14] proposed an innovative distributed cooperative optimal scheduling strategy for integrated energy systems (IES) based on edge computing and consistency algorithms. Coordinating the three energy subsystems ensures their collaborative work to achieve the optimal operation of the system as a whole. It incorporates elements of visual communication to provide a more intuitive and interactive management experience. This system not only achieves efficient data processing but also provides users with an intuitive display of system status through a visual interface. In order to further improve the management efficiency and user experience of the system, we combine visual communication technology to visually display the real-time operating data and scheduling decisions of IES to users in the form of graphics, charts, and other forms. With the booming development of the Internet of Vehicles, the concepts of intelligent transportation and smart cities are increasingly ingrained in people's hearts. Ye et al. [15] introduced blockchain technology to ensure the accuracy and reliability of data transmission and interaction. It also combines visual communication technology to provide users in IoV with a more intuitive and efficient information exchange experience. Visual communication can visually display real-time data such as vehicles, roads, and traffic signals, enabling users to quickly understand traffic conditions and make wiser decisions. By jointly optimizing the offloading decision, caching decision, number of consensus nodes offloaded, block interval, and block size of vehicle computing tasks, it reduces the weighted consumption cost of energy consumption and computing overhead. They are simultaneously improving the information communication throughput and visual communication fluency of blockchain. In order to cope with the large-scale and dynamic characteristics of communication systems, they introduced the asynchronous optimization factor method, which can efficiently handle such complex optimization problems.

In terms of the collaborative application of visual communication and information visualization design, foreign scholars have also conducted research, and using computer-aided design technology, they have constructed information models in the process of visual communication. Through visual design, they have visually processed the information models, effectively improving their readability and understandability. From this, it can be seen that domestic and foreign scholars' research on visual communication and information visualization design mainly focuses on the theoretical level, while the research on the collaborative optimization strategy of the two is relatively less. On the other hand, from the current research situation, the research achievements of domestic and foreign countries on the collaborative application of the two are not rich enough, and there is a lack of discussion on the relevant models and methods of their collaborative application from a theoretical level. Therefore, for the field of visual communication and information visualization design, how to realize their collaborative application is an issue that needs to be solved urgently. Theory and practice, as two inseparable parts of the design process, are also complementary and mutually promoting. Based on this, this paper has conducted a preliminary exploration of the collaborative optimization strategy of the two from three aspects: theory, model establishment, and design experiment verification.

3 COLLABORATIVE OPTIMIZATION MODEL

3.1 Construction Process

CAD technology and virtual reality technology are new types of digital information technology with broad application prospects. CAD technology is a professional 3D modeling tool that can be applied in different fields, such as architecture, machinery, and vehicles, during 3D design. By analyzing and processing 2D drawings, 3D design can be achieved in a short period of time. Virtual reality technology is a new type of human-computer interaction technology mainly applied in fields such as games, movies, and animation, which can achieve simulated operation and visual experience of 3D scenes and has strong flexibility and interactivity in information visualization design. Therefore, CAD and virtual reality technology can help designers save costs and improve efficiency in visual communication and information visualization design. The overall architecture of the collaborative optimization model based on CAD and virtual reality technology is shown in Figure 1.

The construction process of a collaborative optimization model based on CAD and virtual reality technology mainly includes three parts. The first step is to preliminarily confirm the key parameters of the three-dimensional collaborative visualization model. This model is a graphical model that simulates the geometric modelling and structural information of the designed information visualization objects.

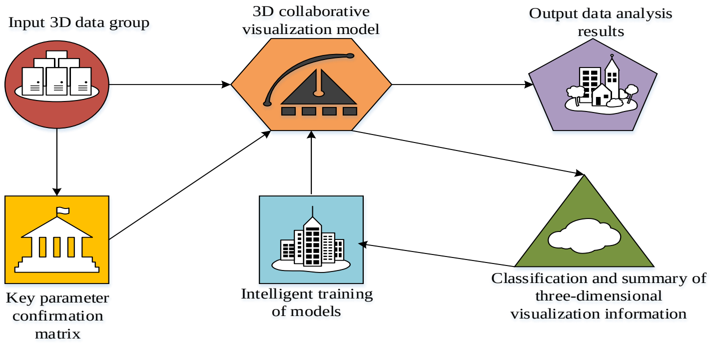

Figure 1: The overall architecture of a collaborative optimization model based on CAD and virtual reality technology.

Based on this, the selection and layout of the information visualization content are carried out. In this study, the designer needs to combine the actual three-dimensional design parameters, extract more detailed parameter data groups, and then reconstruct the three-dimensional model in CAD software based on this information, forming new key parameters of the three-dimensional collaborative visualization model. If the designer needs to design complex information visualization content, they need to analyze and process the three-dimensional model with the aid of CAD software and use the three-dimensional visualization model to display and operate in the computer, realizing the basic functions required in the preliminary three-dimensional collaborative visualization model. After completing the construction of the three-dimensional collaborative visualization model, the designer also needs to use virtual reality technology to render and display the collaborative model in the computer and simulate operations on the three-dimensional scene by changing parameters. The relevant formulas for determining key parameters in this process are as follows:

Set the data source as, and its corresponding three-dimensional rendering function is

$$Q(y_{i,j}) = \frac{\rho y_{i,j} - \sum\limits_{i=1,j=1} \mu y_{i,j} + \xi y_{i+1,j}}{\sum\limits_{i=1,j=1} \mu \rho y_{2i,2j} + \xi y_{2i+1,2j}} \tag{1}$$

The data coordinate is, and the corresponding coordinate parameter change can be obtained according to the data coordinate

$$u = \frac{\rho}{\theta} y_{i,j} + \frac{\mu}{\xi} y_{i+1,j} \tag{2}$$

$$v = \mu z_{i,j} + \xi z_{i+1,j} \tag{3}$$

$$l = \frac{\mu \theta a_{i,j} + \xi a_{2i+1,2j}}{\mu} \tag{4}$$

The corresponding three-dimensional coordinate offset at this time is

$$k = \frac{\mu + \rho}{\mu \theta} \tag{5}$$

After the initial iterative calculation, the corresponding maximum peak function and minimum peak function are

$$M(y_{i,j})=\frac{v}{l}y_{i,j}+\frac{\xi}{\mu+\theta}y_{2i+1,2j} \tag{6}$$

$$K(y_{i,j})=\left|\frac{v+\rho}{l-\theta}\right|y_{i,j}+\left|\frac{\rho}{\zeta}\right|y_{2i+1,2j} \tag{7}$$

In this study there are relevant formulas, each representing the spatial value corresponding to the position, and each representing the standard values of size parameters, rendering standards, visual comparison values, and three-dimensional reconstruction time reference values in the three-dimensional collaborative visualization model, and representing the spatial coordinate information of the data source.

The second step is the design and intelligent training of interactive experiences in the collaborative model. Designers can perform real-time interactive operations on the collaborative model in the computer, achieving information display, visual performance, and other functions in visual communication and information visualization design. In this step, in order to complete the corresponding training for the collaborative model, it is necessary to establish a multi-source heterogeneous dataset and establish a corresponding data management platform for it, so as to manage and store the dataset. At the same time, in order to improve the sharing and flexibility of the dataset, the multi-source heterogeneous dataset can be divided into five parts: basic dataset, data processing layer, data layer, application layer, and system layer. The corresponding algorithm is used to analyze and process the multi-source heterogeneous dataset, thereby achieving the design and training of interactive experiences in the collaborative model. Then, the dataset is managed through the modelling function in CAD software. This not only enables it to achieve intelligent guidance for users and improve their interactive experience but also enables the construction of collaborative optimization models based on CAD and virtual reality technology. The relevant formulas for determining key training parameters in this process are as follows, where the expression of the corresponding training function is:

$$P(y_{i,j})=\frac{\sum y_{i,j}+\sum y_{2i+1,2j}}{\mu+v+l+k} \tag{8}$$

After several training sessions, the corresponding transformation matrix and the intrinsic matrix are:

$$A=\begin{bmatrix}\mu y_{i,j} & 0 & 0\\ 0 & \rho y_{2i,j} & l\\ k & 0 & \theta y_{i,2j}\end{bmatrix} \tag{9}$$

$$B=\begin{bmatrix}\theta y_{i,j} & \rho y_{2i,j} & \mu y_{i,2j}\\ \rho y_{i,j} & \xi y_{2i,j} & l y_{i,j}\\ \mu y_{i,j} & k y_{i,j} & \theta y_{2i,2j}\end{bmatrix} \tag{10}$$

After operating the above matrix, its corresponding transformation relationship is

$$A=B^{-1}A^{T} \tag{11}$$

The corresponding singular value decomposition matrix at this time is

$$U=A^{-1}B^{-1}A^{T}+B^{-1}B^{T}A^{T} \tag{12}$$

The corresponding feature matrix at this time is

$$W=\frac{\mu+\xi}{\rho+\theta}ABB^{T}A^{T} \tag{13}$$

After computing and organizing the relevant data in this study, the corresponding spatial feature vector expression is

$$t = \begin{bmatrix} \rho v \\ \theta u \\ \mu k \end{bmatrix} \tag{14}$$

After training, the expression it should satisfy is

$$At + B^T t^{-1} = 0 \tag{15}$$

After several cycles of training, the corresponding error formula is

$$e = \sum_{i=1} \sum_{j=1} y_{i,j} \tag{16}$$

The error degree formula at this time should satisfy

$$\left| e \right| \leq 0.05 * \frac{\mu + \theta}{\xi} \tag{17}$$

The third step is to complete the optimization and final construction of the collaborative optimization model. Based on the second step, the information visualization content in the collaborative model can be selected and arranged according to the requirements of the actual task, and optimized in combination with the actual application situation to achieve the best visual conveyance effect, thereby providing a good design idea and method for visual conveyance and information visualization design. After completing the construction of the three-dimensional collaborative visualization model, designers can use virtual reality technology and three-dimensional modelling software to render the collaborative model in real time to achieve the best visual conveyance effect. At the same time, they can also provide intelligent guidance to users based on the parameters and information in the collaborative model to improve the user's interactive experience. For example, if a designer needs to integrate and optimize information such as component names, appearance, and colour matching of a product, then use CAD software to convert this information into a three-dimensional model, and use virtual reality technology to visualize the information visualization content, thereby achieving intelligent guidance for users.

3.2 Preliminary Application

After constructing a collaborative optimization model based on CAD and virtual reality technology, this study analyzed and summarized the common visual communication tasks and visualization design requirements in different fields according to their relevance to verify their application effect in visual communication and information visualization.

Firstly, when it comes to multiple common visual communication tasks, the collaborative optimization model can prioritize the tasks and rank them according to their importance. Then, it can optimize them based on their importance in improving the high-quality completion efficiency of visual communication tasks. For example, in the case of poster design, the collaborative optimization model can optimize the colour matching, font size, and layout of the poster to improve the cognitive efficiency of the designer in this task. After designing the poster, the designer needs to analyze the information needs of users and then select and arrange the information visualization content in the poster according to their needs. Meanwhile, after using CAD software to complete the poster design, the designer needs to optimize it based on actual application scenarios to achieve the best visual communication effect and improve the cognitive efficiency of users during the visual communication process. The results of task prioritization are shown in Figure 2.

From Figure 2, it can be seen that the collaborative optimization model has better task prioritization efficiency than the traditional model. When the number of data analyses reaches 50, its corresponding indicators exceed 100, indicating that the collaborative optimization model has good task prioritization capabilities.

Secondly, when visualizing different styles of tasks in a collaborative optimization model, it is necessary first to determine the characteristics of the target audience.

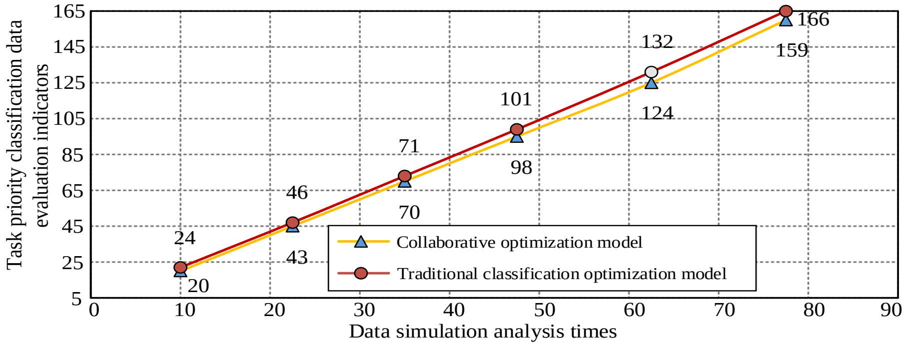

Figure 2: The results of collaborative optimization for task priority classification in traditional models.

In order to improve the efficiency of collaborative optimization for visual communication tasks, analysis can be conducted from the following two aspects: First, during the design process of visual communication tasks, users need to be divided into different target groups based on their types, and then targeted information communication designs need to be carried out for different groups. For example, for designer-design tasks, the target group is professionals and related practitioners with certain aesthetic abilities, and the main purpose is to help designers improve work efficiency and product design quality. Second, for user-design tasks, the target group is the general public and ordinary users with certain aesthetic abilities. When optimizing user-design tasks, it is necessary to consider the different information needs, design styles, visual characteristics, etc. of different user groups to achieve the best visual communication effect. The classification results of visualization presentation styles are shown in Figure 3.

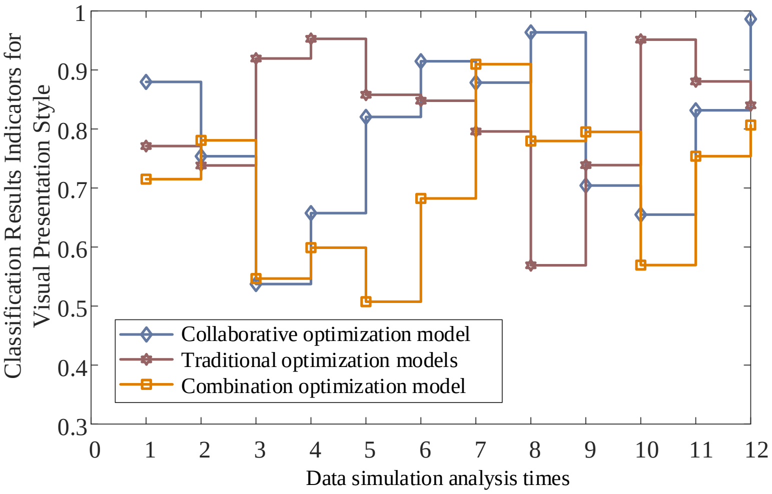

Figure 3: Classification results indicators for visual presentation style of collaborative optimization models.

From the results in Figure 3, it can be seen that with the increase in data analysis times, the corresponding visualization style classification result indicator data page presents different results. When the analysis times reach more than 6, the corresponding classification result indicators can basically stabilize at above 0.8, while the traditional model can only stabilize at above 0.6. Therefore, the collaborative optimization model has better classification ability compared to the traditional optimization model.

Finally, before outputting different visual communication and information visualization design schemes, the collaborative optimization model needs to conduct an error-degree correction analysis. When the error degree meets the minimum standard, the relevant design scheme is output, otherwise, multiple parameter adjustment analyses are conducted. Meanwhile, when optimizing the visual communication design scheme, it is also necessary to consider the different cognitive abilities and information needs of different user groups and adjust it according to the specific situation of designers and users to achieve the best visual communication effect. When each scheme still does not achieve the desired effect after multiple parameter adjustments, it is necessary to update the collaborative optimization model in time to make it improve continuously, so that the model can complete the design task at the fastest speed.

3.3 Optimization Strategy

This research starts from the perspective of design practice, and based on the characteristics and advantages of CAD and virtual reality technology, divides their application in visual communication and information visualization design into four stages, namely, the pre-preparation stage, the mid-operation stage, the post-effect feedback stage, and the post-assessment stage. Based on this, it optimizes from aspects of collaborative optimization theory model construction, design application in practical links, and user effect feedback.

Firstly, when classifying the priority of tasks, the collaborative optimization model needs to classify the tasks according to their attribute values and determine their priority. For example, when classifying the priority of information visualization design tasks, they can be classified into three types: first, according to the goal of visual communication; second, according to the process of visual communication design; and third, according to the effect of visual communication design. Through the above preliminary application analysis, it can be seen that when classifying the priority of tasks in visual communication and information visualization design, it is necessary to comprehensively consider the goals of visual communication design and the process of information visualization design. CAD and virtual reality technology can achieve the integrated application of these two factors. Therefore, when carrying out visual communication and information visualization design, it is necessary to combine the advantages of both to classify tasks. This can prevent the collaborative optimization model from relying on single parameters or high-weight parameters, effectively avoiding errors in subsequent output results. The process of determining and classifying attribute values for different tasks in the collaborative optimization model is shown in Figure 4.

Secondly, when the collaborative optimization model determines the characteristics of the target population corresponding to the output design scheme, it also needs to combine the data set corresponding to the subjective cognition of different characteristic populations. When comparing the design features corresponding to the output of the visual communication design scheme with the subjective cognitive data set of the target population, it needs to be corrected to ensure the effectiveness of the output results. Through the above preliminary application analysis, it can be seen that when outputting results of the collaborative optimization model, it is necessary to comprehensively consider the subjective cognition of different target populations, the difference between the output effect of the scheme and the subjective cognition of the target population, and the difference between the output effect of the scheme and the high-quality case data set. A comprehensive judgment of these three different characteristics is needed to ensure the effective correction of the design scheme for the characteristics of the target population. For example, when analyzing three types of groups in the process of visual communication and information visualization design, they can be effectively corrected through the above methods, which can effectively reduce the frequency of correction of the output scheme. The weighted analysis and judgment results of the collaborative optimization model for different threshold vector groups in different dimensions are shown in Figure 5.

From the results in Figure 5, it can be seen that the improved collaborative optimization model can maintain a stable state in different dimensional vector groups as the number of analyses increases (from 10 to 100), and it has better output effects.

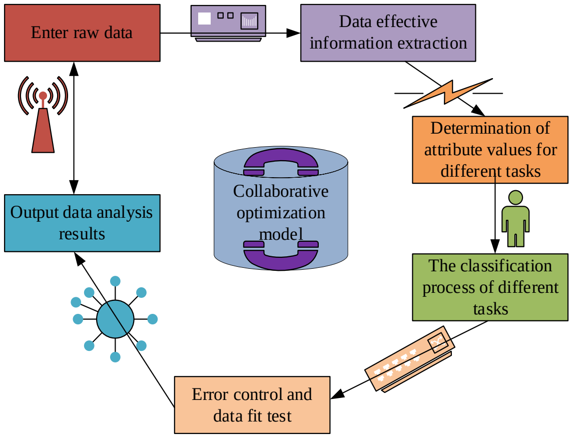

Figure 4: The process of determining and classifying attribute values for different tasks in collaborative optimization models.

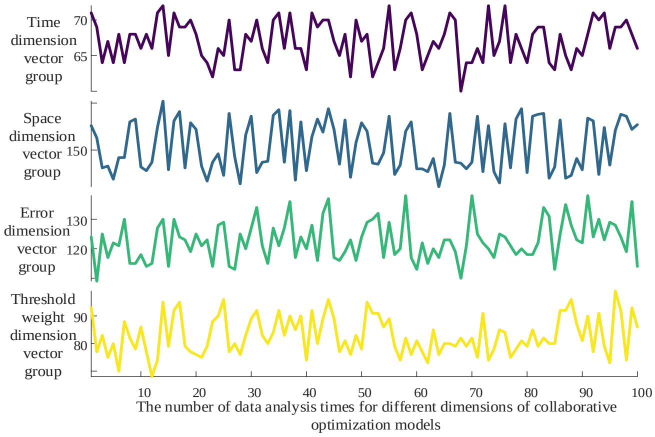

Figure 5: The weight analysis and judgment results of collaborative optimization models for threshold vector groups of different dimensions.

This is because the collaborative optimization model needs to set different dimensional threshold vector groups to judge the output results when conducting error-degree correction analysis. This can avoid the problem of excessive error degree in the output results due to the large error degree between different dimensional threshold vector groups, and also avoid the problem of too small error degree in the output results due to the small error degree between different dimensional threshold vector groups. When conducting error degree correction analysis on visual communication design schemes, it can combine multiple different dimensional threshold vector groups into a new dimensional threshold vector group by setting different dimensional weight combinations.

4 EXPERIMENTAL DESIGN, RESULTS, AND ANALYSIS

4.1 Experimental Design Process and Preliminary Results

In order to verify the application effect of visual communication and information visualization design, this study designed different groups of experiments according to their actual application types and took the design of a car hub, which is often used in design practices, as an example. The car hub was processed through three-dimensional modelling, and its three-dimensional model was established using CAD software. Through appropriate modifications to the model, the final three-dimensional visualization model was obtained. During the collaborative optimization model experiment verification process, this study also used three groups of different sizes and types of car hubs for comparison. Afterward, the three-dimensional model was imported into a virtual reality device, and through corresponding interactive operations, designers and users were allowed to obtain visual experiences in a virtual reality environment, thereby analyzing the satisfaction of designers and users with the car hub design. The superiority, scheme output time, user satisfaction, and other normalized data results of the five subsystems (CAD system, VRML system, VQI system, VR system, and CAX system) in the collaborative optimization model corresponding to the scheme in the experiment are shown in Figure 6.

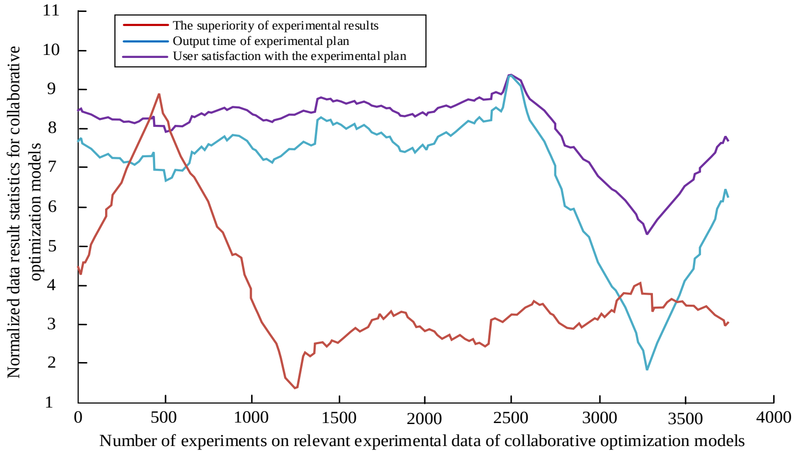

Figure 6: Preliminary experimental results analysis of collaborative optimization model.

From the results in Figure 6, it can be observed that the visual experience in the virtual reality environment is significantly superior to that of the original 3D model. Moreover, the visual experience designed in the virtual reality environment is more intuitive, vivid, and realistic compared to the original 3D model.

4.2 Experimental Results Analysis of Collaborative Optimization Model

In order to further analyze the experimental results of the collaborative optimization model objectively, this study conducted quantitative analysis on the overall error degrees corresponding to the five subsystems (CAD system, VRML system, VQI system, VR system, and CAX system) in the model, and determined them using normalized international standard values, resulting in experimental analysis results as shown in Figure 7.

From the results in Figure 7, it can be found that with the increase of analysis times (1 time-55 times), the five subsystems in the model can accurately complete their respective tasks, and the overall performance of the model is also ideal, meeting the requirements of the design task, and the overall error degree is very small (the overall error degree is between 0.2% and 0.4%). At the same time, the model can also achieve good coordination and cooperation among multiple subsystems, ensuring the overall performance of the collaborative optimization model. Among them, in the collaborative optimization between the CAD system and VRML system, the CAD system, as the main optimization object, can complete tasks at a higher accuracy and faster speed; in the collaborative optimization between the VQI system and VR system, VR system, as the main optimization object, can complete tasks at a higher accuracy and faster speed; in the collaborative optimization between CAX system and CAX software, CAX software is the main optimization object.

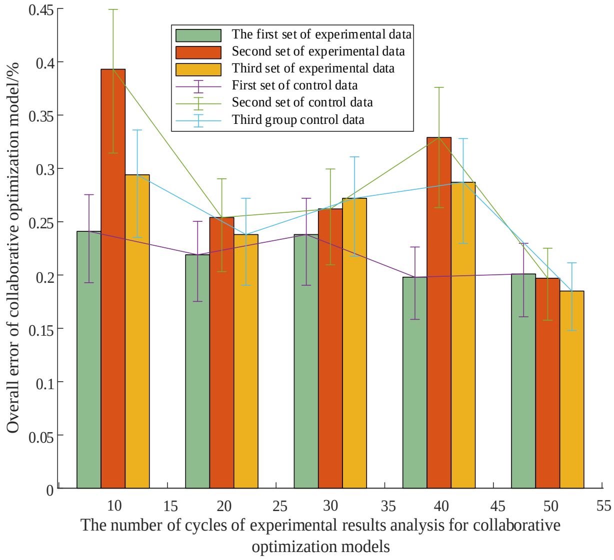

Figure 7: Overall error analysis of experimental results of collaborative optimization models.

5 CONCLUSIONS

In recent years, with the continuous development of computer technology, multimedia technology and network technology, the research in the field of visual communication and information visualization design has also developed rapidly. Among them, the application of CAD and virtual reality technology in the field of visual communication and information visualization design is currently a hot research topic. However, the collaborative application research of CAD and virtual reality technology in visual communication and information visualization design is still in its infancy, and there are still certain limitations. Based on this, this paper analyzes the collaborative application of CAD and virtual reality technology in visual communication and information visualization design, discusses the advantages and characteristics of the two in information transmission, proposes the theoretical basis and basic principles for their collaborative application, and discusses the specific methods of their collaborative application from three aspects: theoretical research, practical application, and design practice. This paper aims to further enrich the theoretical system of visual communication and information visualization design through research on the collaborative optimization method of CAD and virtual reality technology in visual communication and information visualization design so as to provide a certain reference for their future collaborative application.

Xiangjin Zhu, https://orcid.org/0009-0007-0036-9771
Jinyin Peng, https://orcid.org/0009-0007-0200-0652
Wei Bi, https://orcid.org/0009-0006-8666-3906
Fangyu Xiang, https://orcid.org/0009-0000-9415-3873
Chaoqiao Yang, https://orcid.org/0009-0002-5959-0749

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