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

Exploration of Winter Sports Industry Brand Design Integrated with Knowledge Graph and Co-creative Platform in Virtual Reality

Liang Xu[1] and Shiyong Hu[2]

[1] Department of Arts, Jilin Police College, Changchun 130117, China, xuliang@jljcxy.edu.cn
[2] Android Software CENTER, TPV Display Technology (Xiamen) Co., Ltd, Xiamen 363000, China, husyong@163.com

Corresponding author: Liang Xu, xuliang@jljcxy.edu.cn

Abstract. With the rapid development of winter sports industry sports, the market size of the winter sports industry continues to expand, driving winter sports industry brand design to become a new research topic. Brand design under traditional design patterns still remains flat and two-dimensional, which makes it difficult to meet the development needs of the winter sports industry. This study explores a design mode combining virtual reality with CAD by utilizing knowledge graph and virtual reality technology, transforming abstract concepts such as entities, relationships, and knowledge into visual graphic expressions, thereby improving the efficiency and quality of brand design and creating a virtual space with information as the link, in order to provide new ideas for related industries. Experimental results indicate that by integrating knowledge graph technology, the practicality and collaboration of CAD winter sports industry brand design with a virtual reality co-creation platform can be effectively enhanced.

Keywords: Knowledge Graph; CAD Technology; Winter sports industry Brand Design; Virtual Reality Technology; Co-creation Platform
DOI: https://doi.org/10.14733/cadaps.2024.S28.83-96

1 INTRODUCTION

With the gradual realization of the goal of "300 million people participating in winter sports industry sports," China's winter sports industry has developed rapidly. Under the influence of the global pandemic, information technologies represented by virtual reality have driven the development of the winter sports industry, and digital experiences combining virtual reality, AR, and other technologies with brand design have gradually become a new trend. In the field of brand design, designing new products based on user needs and requirements is a core element to ensure brand success. However, existing digital design tools often face a trade-off between pursuing accuracy in user experience and providing intuitive and user-friendly interfaces for end-users. To overcome this challenge, digital design tools provide an innovative solution that allows users to actively participate

in the design process and directly interact with the concepts of future products. Arrighi and Mougenot [1] are based on a hybrid reality hardware/software system that integrates virtual reality environments and intuitive physical interfaces. Using 3D game engines as power sources, providing users with rich interactive content that is presented in highly realistic virtual reality. Virtual reality (VR) technology has shown extensive application potential in multiple industries, with manufacturing, engineering, and healthcare being particularly prominent. Combining VR technology and knowledge graph, Bu et al. [2] proposed an innovative brand design method. Especially in creating a user-friendly brand experience, enhancing interaction between users and brands, and achieving personalized and differentiated product design, VR technology has demonstrated tremendous value. Knowledge graph, as a powerful tool for organizing and managing information, can help brand designers collect, analyze, and utilize consumer data more systematically, thereby gaining a deeper understanding of consumer needs and preferences. Simultaneously utilizing knowledge graph technology to collect and analyze data generated by consumers during the experience process, in order to continuously optimize design and improve user satisfaction. This method aims to be user-centred and provide consumers with an immersive brand experience through VR technology.

Integrating style-related goals into shape design is an indispensable part of enhancing product appeal. Chen et al. [3] proposed an artificial intelligence-driven approach that assists in the automated discovery of brand-related features through knowledge graphs. Therefore, the application of algorithms in style capture and reuse is limited by the challenge of design descriptiveness and has not fully utilized the potential of automated data-driven methods. Parameter modelling based on small curve datasets and vectorization based on large pixel datasets. Cui et al. [4] focused on the research topic of brand visual identity design structure and performance in the era of new media. How does brand visual identity design respond to current social changes in the era of new media? Adapt to the needs of the times and respond to the needs of brand owners for brand communication in the context of new media. It summarizes the impact and performance of media in this stage on brand visual identity design structure and summarizes the entire article. Through this study, we can address the new demands of brand visual identity design in the era of new media. Briefly discuss the relevant history and theoretical ideas that influence the structure of visual recognition design, and analyze the media communication methods and reasons at each stage. Through investigation, research, comparison, analysis, and summary of case studies, this study aims to explore the changes and differences in the characteristics, types, and design methods of brand identity design in the new media environment. Research the design concept and expression of brand identity design in traditional media. Changes in the design philosophy and performance of brand identity design in the new media community. Summarize and summarize the brand identity design performance in the new media environment. Provide theoretical summaries for research.

At the same time, combining the brand designer's in-depth understanding of the target consumer group and unique perception of body shape. Through these experiments, we collected a large amount of data related to brand design, including design elements, colour matching, material selection, etc. A knowledge graph presents knowledge in the form of a graph, which can clearly display the relationships between brand design elements, including their hierarchical structure, attributes, associations, etc. In order to further expand the system to the field of brand design, they optimized and enhanced it to support personalized design recommendations and virtual demonstrations related to the brand [5]. In the process of knowledge graph brand design, the traditional encoder-decoder architecture is often used to generate brand-related strategies, suggestions, or analysis reports. To alleviate this problem, Du et al. [6] borrowed the idea of contrastive learning and proposed a contrastive framework to enhance the generalization ability of brand design models. Dzyabura and Peres [7] introduced an innovative brand management platform and analysis method based on visual inspiration and knowledge graphs in the field of brand management. Specifically, Haruna et al. [8] employed a transformer model based on bidirectional encoder representation (BERT) for collaborative entity/relationship recognition. Through the relationship recognition process of dependency parsing, the semantic relationships between these entities can be further explored, and a rich knowledge network can be formed. A method that combines advanced natural language

processing techniques to construct an intuitive and easily understandable knowledge reasoning framework, thereby promoting the application of AM in brand design.

Virtual reality technology can break through the spatial limitations of traditional design, providing designers with a broader design space. However, virtual reality technology is not yet mature, and there is a certain gap between theory and practical application. For example, although some virtual reality systems support users to interact in virtual scenes, the user experience is not satisfactory and cannot meet users' needs. Additionally, a knowledge graph is a new technology and carrier for organizing, describing, and managing data in graph databases. As a novel way of knowledge representation, knowledge graphs have great potential for handling complex problems in various knowledge domains. When combined with virtual reality technology, it can break through the spatial limitations of traditional design and improve the efficiency and quality of brand design. However, there is relatively little research on the combination of knowledge graph and virtual reality by scholars both domestically and internationally, and there are certain limitations. For example, only semantic expressions of entity relationships are considered, while issues such as modelling and maintenance of knowledge graphs are lacking. Therefore, in the design process, how to combine knowledge graph and virtual reality technology to enhance design quality is a topic worthy of research. This study combines knowledge graphs with virtual reality, constructs a CAD winter sports industry brand design platform integrating knowledge graphs and virtual reality, and verifies the feasibility of the platform through experiments.

2 THE CURRENT RESEARCH STATUS

In the field of brand design, traditional methods often rely on the designer's intuition and experience, but such processes often lack systematic data support and interpretability. Kuo et al. [9] proposed an interpretable feedforward (FF) design that does not require backpropagation, aiming to introduce the powerful capabilities of CNN into the field of brand design while maintaining the interpretability and intuitiveness of the design. To construct convolutional layers, we introduce a new signal transformation method called Saab (subspace approximation with adjusted bias) transformation. This FF design adopts a data-centric approach, which deduces the network parameters of the current layer by counting the output of the previous layer in one go. Knowledge graphs and semantic network technology provide semantic interconnection and interrelated information for brand design through data augmentation and network content representation. The purpose of Lampropoulos et al.'s [10] research is to explore how to combine deep learning, semantic web, and knowledge graph technologies to enhance the functionality and services of AR in the field of brand design. AR not only provides fast access to real-time, flowing information but also becomes more meaningful and "vivid" when embedded into specific spatial and temporal frameworks. It briefly introduces the concepts of AR and mixed reality (MR) and delves into the applications of deep learning, semantic web, and knowledge graph technologies in brand design.

In the manufacturing industry, the construction of knowledge graphs faces the challenges of isolated data warehouses and domain-specific knowledge, especially when facing distributed databases with heterogeneous storage and complex patterns. Liu et al. [11] proposed a resource-based method for constructing industrial knowledge graphs. Meanwhile, it has designed an attribute-based data fusion and alignment strategy to ensure that brand design-related data can be accurately and efficiently integrated into the knowledge graph. In the case of limited resources, the accuracy has improved by 36.6% compared to the distribution characteristics, which fully demonstrates the strong applicability of the model under low resource conditions. This platform can not only accurately capture the internal connections between brand elements but also provide a comprehensive analysis of the brand value chain, providing strong data support and a decision-making basis for brand designers. In the field of brand design, knowledge graphs (KGs) play a crucial role in integrating information from various aspects such as brand history, market trends, and consumer feedback, providing strong decision support for designers and brand managers. These noises may include inaccurate information, conflicting relationships, or redundant data, thereby affecting the quality of the knowledge graph and the effectiveness of downstream tasks. Ma et al.

[12] proposed a high-precision brand design knowledge graph noise detection method based on path credibility and triplet embedding (PTrustE). On the one hand, these methods may find it difficult to accurately detect noisy triplets with conflicting relationships, namely entity relationship entity combinations that contain incorrect or misleading information. With the diversification of data sources and the growth of data volume, automatically or manually constructed brand design knowledge graphs often inevitably contain noise when adding heterogeneous data. The core idea of this method is to evaluate the credibility of triplets by analyzing the path information in the knowledge graph and, based on this, detect and eliminate noise.

In the field of brand design, the concept of human-computer interaction has also received widespread attention, especially in achieving hybrid automation and intelligence in the brand design process. Designers need to quickly iterate design proposals and receive real-time feedback to ensure that the design aligns with brand concepts, market demands, and consumer preferences. A new form of collaboration is exploring the synergistic effects of human-machine collaboration to improve the efficiency and quality of brand design. In the process of brand design, the requirements for flexibility, adaptability, and innovation make the design and optimization of human-machine collaborative systems complex and require careful consideration. Time-based continuous simulation and virtual reality technology have brought new solutions to brand design. By using continuous simulation, Malik et al. [13] tested and validated design solutions in a secure virtual space, predicted market reactions and consumer behavior, and identified potential issues in advance for optimization. In the field of brand design, in order to support subtle differences in collaboration within design teams and with clients, researchers have begun exploring the potential of augmented reality (AR), aiming to help achieve local or remote collaboration scenarios. Marques et al. [14] analyzed the different dimensions that should be considered when analyzing the contribution of AR to brand design collaboration.

To overcome these challenges, Xie et al. [15] were inspired by graph-based knowledge systems and proposed a multi-layer IoT middleware architecture based on knowledge graphs. The Internet of Things not only provides ubiquitous intelligence and universal connectivity but also provides brand designers with rich data sources and user behaviour insights. In the multi-layer IoT middleware based on knowledge graphs, they introduced a new layer to bridge the gap between IoT devices with different communication protocols. This architecture not only effectively eliminates heterogeneity in brand design systems but also provides richer and more accurate data support for brand designers. In the field of brand design, traditional recommendation systems typically rely on offline user data to train models and recommend relevant design elements, market trends, or strategies to designers or brand managers. The existing CRS models also face the problem of insufficient contextual information modelling when dealing with recommendation tasks in the field of brand design. Zhao et al. [16] proposed a context information enhancement model tailored for CRS, namely Knowledge Graph Enhanced Sampling (KGenSam). CRS can respond more quickly and adapt to the changing needs of users by capturing their interactive behavior in real-time. In the field of brand design, a knowledge graph can contain rich information such as brand history, consumer behaviour, market trends, and competitor strategies. Firstly, a fuzzy sample sampler is used to sample samples with high uncertainty from a knowledge graph, which can reveal potential but not explicitly expressed interests and preferences of users.

In the above research, although scholars both domestically and internationally have conducted certain research on winter sports industry brand design and innovation in co-creation platforms, they have not yet provided explicit solutions. Moreover, the research primarily focuses on exploring the brand design process using winter sports industry brand design as an example, without studying the combination of virtual reality technology and knowledge graphs. Furthermore, in terms of innovation in co-creation platforms, research by scholars both domestically and internationally mainly concentrates on consumer-centric innovation in co-creation platforms, with relatively less research on the integration of co-creation platforms with winter sports industry brand design [20]. Additionally, the combination of virtual reality technology with traditional design patterns is also a new research direction. Therefore, it is essential to propose a brand design model based on knowledge graphs and virtual reality on the basis of previous research to provide new ideas for winter sports industry brand design.

3 CONSTRUCTING AND OPTIMIZING CAD WINTER SPORTS INDUSTRY BRAND DESIGN INTEGRATED WITH KNOWLEDGE GRAPHS AND VIRTUAL REALITY CO-CREATION PLATFORM

3.1 The Construction Ideas and Concepts of Integrating Knowledge Graphs into CAD Winter Sports Industry Brand Design with Virtual Reality Co-creation Platform

Knowledge graph is a method of knowledge representation based on graph databases. Specifically, leveraging the support of virtual reality technology and CAD design technology, with digitalization, informationization, and intelligence as the core, the study fully utilizes the role of knowledge graphs to construct a co-creation platform integrating knowledge graphs for CAD winter sports industry brand design with virtual reality.

The co-creation platform mainly consists of four modules:

1. CAD Design Module: This module creates a CAD design knowledge graph by processing and storing design data and maintaining and managing it to achieve storage and processing of brand design data.

2. Knowledge Graph Application Module: This module stores and processes brand design data through searching and applying knowledge graphs, and maintains and manages them to control and manage the brand design process.

3. 3D Modeling Module: This module stores and processes brand design data by creating 3D models, and maintains and manages them to control the brand design process.

4. Virtual Reality Technology and CAD Technology Application Module: This module stores and processes brand design data by implementing virtual reality technology and CAD technology applications and controls the brand design process through user interaction.

The fifth module is the CAD winter sports industry brand design co-creation platform based on the integration of knowledge graphs and virtual reality technology. Organically combining knowledge graphs with virtual reality technology achieves the storage and processing of brand design data. The relevant computational formulas applied in the above modules are as follows:

$$Z(x) = \frac{e^{-\mu x}}{1+\mu e^{-x}} + e^{\eta} \tag{1}$$

$$X(x) = \frac{\sqrt{\sum_{i=0}^{\eta} x_i Z(x)}}{\mathrm{Z}(x-1)} \tag{2}$$

$$C\ x\ = \frac{B\ x}{Z\ 2x} + \sqrt{\frac{\lambda^2 \eta x}{\eta + \mu e^{x}}} \tag{3}$$

$$V\ x\ = \frac{\lambda e^{\mu\ x-\eta}}{\eta x^{e+1} + \mu x + e^{\eta\ 2x+\mu}} \tag{4}$$

where $Z(x), X(x), C(x), V(x)$ represents the storage function, correction function, extreme value function, and pairing function, x, x_i denotes the original data of varying dimensions, and η, μ, λ stands for the correction coefficient, standard coefficient, and fusion coefficient.

The CAD winter sports industry brand design and virtual reality co creation platform, which integrates the knowledge map, constructs the CAD winter sports industry brand design knowledge map through the organic integration of the above modules, and maintains and manages it, so as to realize the storage and processing of brand design data, and realize the management and control of the brand design process; Through the search and application of knowledge map, the knowledge map and virtual reality technology are organically combined to build a co creation platform of brand design and virtual reality in the virtual environment, so as to realize the storage and processing of relevant

data in the process of brand design, and realize the management and control of brand design data; Through the query and application of knowledge map, the knowledge map and user interaction are combined to realize the construction of user interaction mode, and finally realize the construction of CAD winter sports industry brand design and virtual reality co creation platform. The schematic diagram is shown in Figure 1.

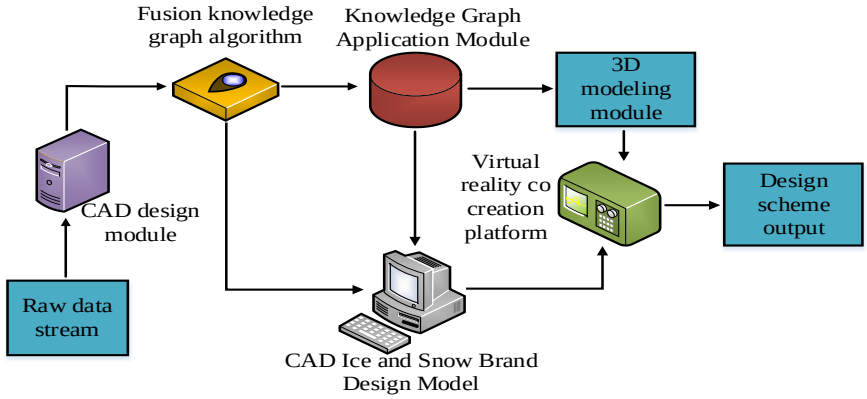

Figure 1: Architecture of a CAD winter sports industry brand design and virtual reality co-creation platform integrating knowledge graphs.

3.2 Analysis of the Operation Process of the Co-Creation Platform of CAD Winter sports industry Brand Design and Virtual Reality Based on Knowledge Map

Based on the architecture process of the above-related modules, this study takes the winter sports industry brand design as an example to establish the operation process of a CAD winter sports industry brand design and virtual reality co-creation platform integrating knowledge map. The specific steps are as follows:

The first step, based on the knowledge of winter sports industry brand design, analyzes the key links of the design and the related technologies, knowledge, and resources involved and classifies them, such as the classification of knowledge, the classification of the design process, etc., to lay the foundation for the subsequent CAD winter sports industry brand design, and then combines the advantages of the knowledge map, sorts out, summarizes and constructs the related technologies and knowledge involved, and completes the construction of the underlying operation process of the knowledge map, and then carries out multi-angle pre-operation analysis of data groups with different dimensions. At this time, the corresponding formulas are as follows:

$$Z'(x) = 2\frac{\lambda}{\mu} + \sqrt{\frac{e^{-\mu x}}{1+\mu e^{-x}}} + e^{\eta} \tag{5}$$

$$X'(x) = \frac{\lambda\eta}{e+\mu x} + \frac{\sqrt{\sum_{i=0}^{\eta} x_i Z(x)}}{\mathrm{Z}(x-1)} \tag{6}$$

$$C'\ x\ = \frac{4\eta B'\ x}{\lambda Z'\ 2x} + \sqrt{\frac{\lambda^2 \eta x}{\eta+\mu e^{x}}} \tag{7}$$

$$V'\ x\ = 2\lambda + \sqrt{\frac{\lambda e^{\mu\ x-\eta}}{\eta x^{e+1} + \mu x + e^{\eta\ 2x+\mu}}} \tag{8}$$

The second step is to use the knowledge map to uniformly model the related technologies, knowledge and resources, and use the relationship model in the knowledge map to model the related technologies, so as to form a unified CAD knowledge map of winter sports industry brand design, and aggregate the relevant feature points based on the knowledge map, and then apply it to the CAD knowledge map of winter sports industry brand design to improve the processing efficiency of related technologies and knowledge, and then use the concepts and relationships in the knowledge map to store and manage the related information involved in the process of CAD winter sports industry brand design, and apply it to the CAD knowledge map of winter sports industry brand design to improve the management efficiency of related technologies and resources. The simulation results are shown in Figure 2.

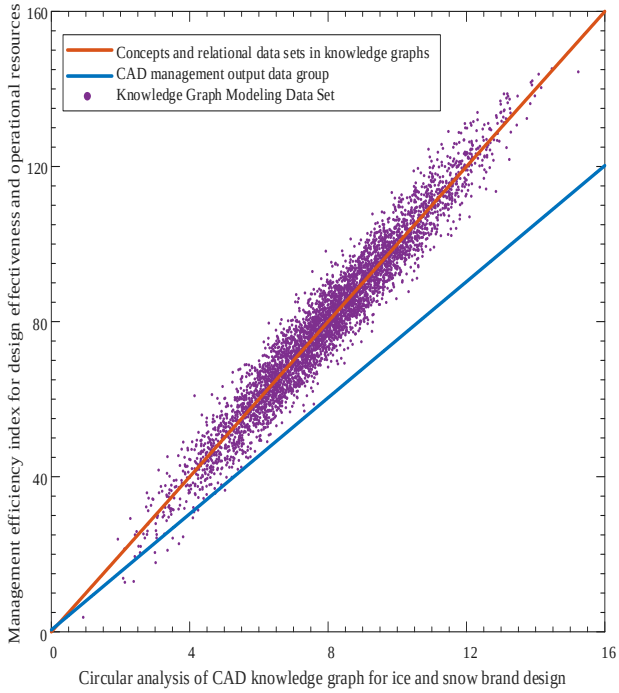

Figure 2: Simulation results of knowledge graph network for unified modelling of technology, knowledge, and resources.

It can be seen from the results in Figure 2 that the simulation results corresponding to the data group corresponding to the knowledge map modelling strategy basically match the fitting results of the data group corresponding to the concept relationship strategy, and the management efficiency index can reach more than 80 when the cycle analysis times reach more than 8, so the knowledge map strategy can effectively improve its management efficiency.

The third step is to retrieve and apply the relevant technologies and resources according to the CAD knowledge map of winter sports industry brand design, set the relevant decision threshold function, and then find out the data groups with high correlation and cluster them so as to construct the CAD knowledge map of winter sports industry brand design, and then retrieve and apply them based on the CAD knowledge map of winter sports industry brand design, and summarize the results of their application, analyze their internal relevance and initial verification, and analyze the application of relevant technologies and resources in combination with user needs and expert experience, so as to obtain preliminary judgment results.

The fourth step is to optimize the preliminary CAD winter sports industry brand design scheme based on the concepts and relationships in the knowledge map and expert experience of CAD winter sports industry brand design and verify it again according to the optimized CAD winter sports industry brand design scheme, so as to obtain the final CAD winter sports industry brand design scheme. Then, the optimized CAD winter sports industry brand design scheme is evaluated, and the evaluation results are fed back to the CAD winter sports industry brand design knowledge map to improve the optimization efficiency of the design scheme. The relevant calculation formulas applied in the above modules are as follows:

$$Z"(x) = \sqrt{3x\frac{3+\lambda}{5-\mu}} + \sqrt{\frac{e^{-\mu x}}{1+\mu e^{-x}}} + e^{\eta} \tag{9}$$

$$X"(x) = \frac{e+\mu\lambda}{e-\eta} + \sqrt{\frac{\lambda\eta}{e+\mu x}} + \frac{\sqrt{\sum_{i=0}^{\eta} x_i Z(x)}}{\mathrm{Z}(x-1)} \tag{10}$$

$$C"\ x\ = \frac{\sqrt{\frac{4\eta B'\ x}{\lambda Z'\ 2x}} + \sqrt{\frac{\lambda^2\eta x}{\eta+\mu e^{x}}}}{\lambda x} \tag{11}$$

$$V"\ x\ = \frac{2\lambda + \sqrt{\frac{\lambda e^{\mu\ x-\eta}}{\eta x^{e+1} + \mu x + e^{\eta\ 2x+\mu}}}}{2+\lambda x+\eta\mu e^{x}} \tag{12}$$

The fifth step is to establish a CAD winter sports industry brand design and virtual reality co-creation platform by combining knowledge mapping and user interaction technology and applying it to the "winter sports industry" brand design according to the above steps. By building this platform, the "winter sports industry" brand design and virtual reality co-creation can be realized, so that users can intuitively perceive the "winter sports industry" brand through this platform. The simulation results are shown in Figure 3.

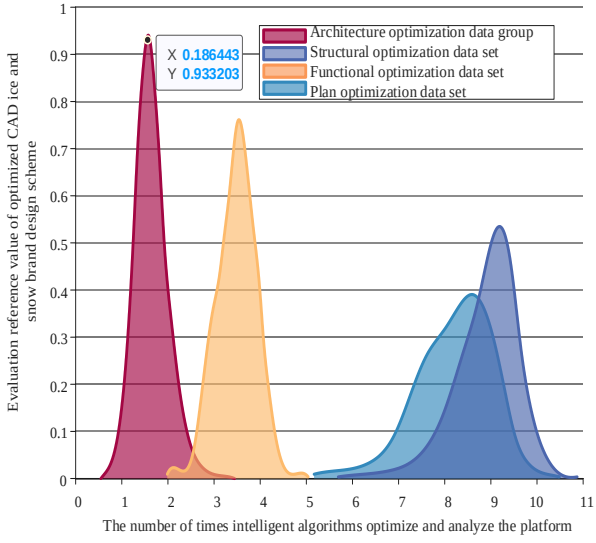

Figure 3: Simulation analysis results of perceived effects of CAD winter sports industry brand design based on knowledge graph establishment.

From the results in Figure 3, it can be seen that the CAD winter sports industry brand design and virtual reality co-creation platform integrated with a knowledge map can effectively improve the design effect of winter sports industry brands, and can well complete the internal relevance comparison, and the peak value of the architecture optimization data group can reach 0.933203 in the first two cycles.

3.3 Optimization strategy of CAD winter sports industry Brand Design and Virtual Reality Co-Creation Platform Based on Knowledge Map

In this study, a CAD winter sports industry brand design and virtual reality co-creation platform integrated with a knowledge map is proposed. It is found that there are still some shortcomings in the simulation process, especially in the process of collaborative design of different winter sports industry brands. Therefore, this study proposes an optimization strategy to solve these problems and improve the intelligence of the platform from multiple levels.

Firstly, this study optimized the overall architecture of the platform. Through the analysis of the existing CAD winter sports industry brand design and virtual reality co-creation platform, it found out the existing shortcomings and problems, combined with a variety of intelligent algorithms and designed a variety of operation rules to optimize the overall architecture of the platform, including the optimization of the overall architecture of the platform, the optimization of the functional structure of the platform and the optimization of the specific functions of the platform, and then optimized the CAD winter sports industry brand design and virtual reality co-creation platform, and improved it on this basis. Specifically, by using knowledge map technology, combined with the original CAD winter sports industry brand design knowledge map, it constructed the CAD winter sports industry brand design knowledge map; Then, the original CAD winter sports industry brand design scheme is optimized, and the optimized CAD winter sports industry brand design scheme is constructed; Finally, the optimized CAD winter sports industry brand design scheme is evaluated, and the evaluation results are fed back to the CAD winter sports industry brand design knowledge map, so that it can play a better role, so as to improve the intelligent degree of the platform. The optimized results are shown in Figure 4.

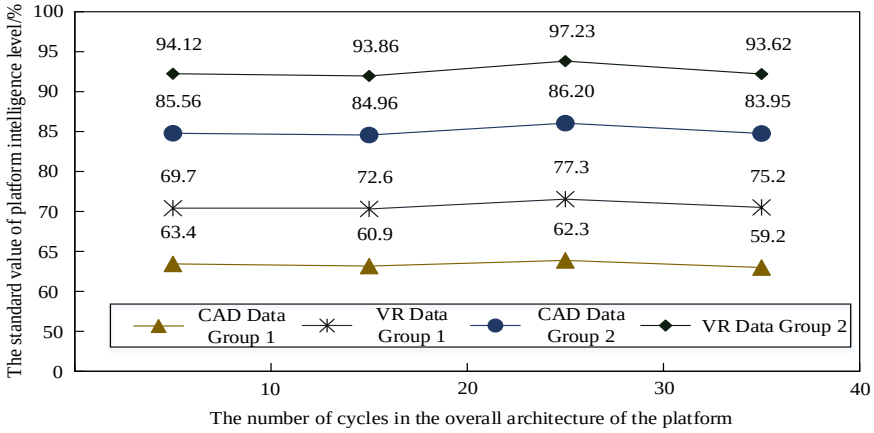

Figure 4: Preliminary results of optimizing the CAD winter sports industry brand design and virtual reality co-creation platform by integrating knowledge graphs.

It can be seen from Figure 4 that the results of the number of cycles of the CAD data group and VR data group under the overall framework of the platform are relatively stable, with the highest value of 97.23%, and most of the results are above 75%. Therefore, the co-creation platform integrated with knowledge map optimization has a good improvement effect.

Secondly, on the basis of fully understanding the operation principle and process of the co-creation platform of CAD winter sports industry brand design and virtual reality, combined with the feedback and opinions of users, the KNN algorithm is used to train and optimize the entities in the knowledge map of CAD winter sports industry brand design. Specifically, firstly, the knowledge map technology is used to construct the knowledge map of CAD winter sports industry brand design; Then the optimized CAD winter sports industry brand design scheme is evaluated, and the evaluation results are fed back to the CAD winter sports industry brand design knowledge map, so that it can play a better role; After completing these works, the specific functions of the platform will be optimized, including the overall architecture of the platform, the functional structure of the platform and the specific functions of the platform, so as to make the CAD winter sports industry brand design and virtual reality co create a platform to better serve users. For example, in the overall architecture of the platform, the contact and interaction between different designers can be improved by adding external links and internal links, and in the functional structure of the platform, the design efficiency and quality can also be improved by adding modules and establishing links between modules. The corresponding formula is as follows:

$$Z'''(x) = \frac{\sqrt{3x\dfrac{3+\lambda}{5-\mu}} + \sqrt{\dfrac{e^{-\mu x}}{1+\mu e^{-x}}}}{\lambda + e} + e^{\eta} \tag{13}$$

$$X'''(x) = \frac{\sqrt{\dfrac{e+\mu\lambda}{e-\eta}} + \sqrt{\dfrac{\lambda\eta}{e+\mu x}}}{\lambda\mu} + \frac{\sqrt{\sum_{i=0}^{\eta} x_i Z(x)}}{\mathrm{Z}(x-1)} \tag{14}$$

$$C'''\ x\ = 2 + \lambda\frac{e^{x}}{\mu + x} + \frac{\sqrt{\dfrac{4\eta B'\ x}{\lambda Z'\ 2x}} + \sqrt{\dfrac{\lambda^{2}\eta x}{\eta + \mu e^{x}}}}{\lambda x} \tag{15}$$

$$V'''\ x\ = 3\mu\lambda + \frac{2\lambda + \sqrt{\dfrac{\lambda e^{\mu\ x-\eta}}{\eta x^{e+1} + \mu x + e^{\eta\ 2x+\mu}}}}{\sqrt{2+\lambda x} + \eta\mu e^{x}} \tag{16}$$

Finally, we should innovate on the basis of the original platform functions to make it more intelligent, humanized and personalized, and realize these functions in the co-creation platform of CAD winter sports industry brand design and virtual reality to make it more intelligent. Specifically, this study uses the knowledge map technology, combined with the original CAD winter sports industry brand design knowledge map, to construct the CAD winter sports industry brand design knowledge map; Then it is applied to the co-creation platform of CAD winter sports industry brand design and virtual reality, and the optimized CAD winter sports industry brand design scheme is constructed; Finally, the optimized CAD winter sports industry brand design scheme is evaluated, and the evaluation results are fed back to the CAD winter sports industry brand design knowledge map, so that it can play a better role, so as to improve the intelligent degree of the platform. The results of the second optimization are shown in Figure 5.

It can be seen from the experimental results in Figure 5 that the co-creation platform can effectively solve some specific design requirements and user needs of related projects in this experiment, and when the number of algorithm analyses reaches more than 5, the reference value of design scheme evaluation can reach more than 10 points. This is because the knowledge map in the platform can help users quickly extract and query the knowledge in the winter sports industry brand design scheme, and apply this knowledge to the co-creation platform of CAD winter sports industry brand design and virtual reality, so as to improve the intelligence of the platform.

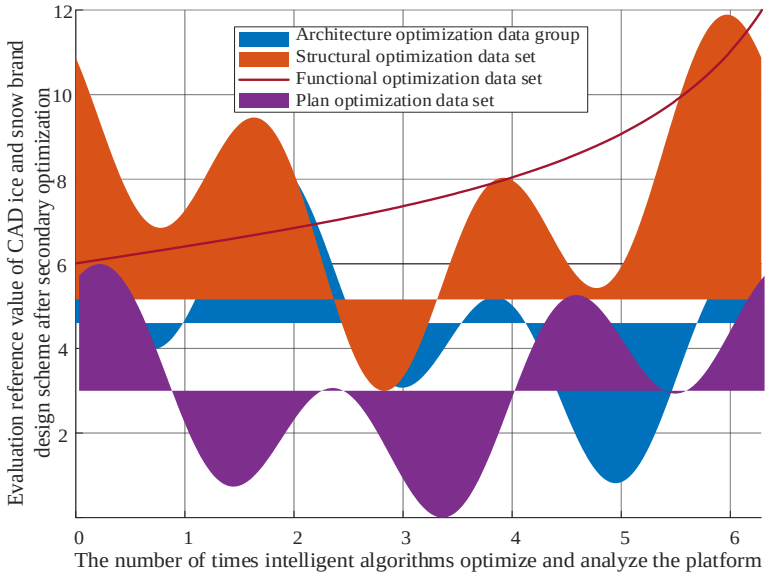

Figure 5: Secondary optimization results of CAD winter sports industry brand design and virtual reality co-creation platform integrating knowledge graph.

4 EXPERIMENTAL RESULTS AND ANALYSIS

4.1 Design Process of Confirmatory Experiment

This research is based on the innovation and entrepreneurship training project for college students in a domestic university and takes the "winter sports industry" brand design as the research object. Through the integration and application of knowledge mapping technology, the "winter sports industry" brand design and virtual reality co-creation platform are realized. On this platform, firstly, the university students' innovation and entrepreneurship training project was investigated, and four groups of different research directions and contents were determined; Then, taking the "winter sports industry" brand design as an example, a CAD winter sports industry brand design and virtual reality co creation platform integrated with knowledge map was established to realize the visual display of CAD winter sports industry brand design; Finally, KNN algorithm is used to train and optimize the relationship in the CAD knowledge map of winter sports industry brand design, to obtain the entity relationship in the CAD knowledge map of winter sports industry brand design, and the entity relationship of the existing knowledge map is used to verify the co creation platform. The experimental results are shown in Figure 6.

It can be seen from the results in Figure 6 that the brand design efficiency, the error degree of the design scheme and the overall time-consuming of the design scheme have significantly improved, and the brand design efficiency has reached the peak value of 6.68 standard value after the 30th cycle, while the error degree of design scheme has basically decreased to 1 standard value after the 60th cycle. Therefore, the co-creation platform of CAD winter sports industry brand design and virtual reality integrated with a knowledge map has an obvious improvement effect after optimization. This is because the co-creation platform integrated with the knowledge map can enable users to carry out collaborative design in the platform and improve the intelligence of the platform. In addition, because the co-creation platform integrated with a knowledge map has knowledge in multiple application fields and different fields, the platform can also enable users to search and select different fields of winter sports industry brands during collaborative design, thus improving the efficiency of collaborative design.

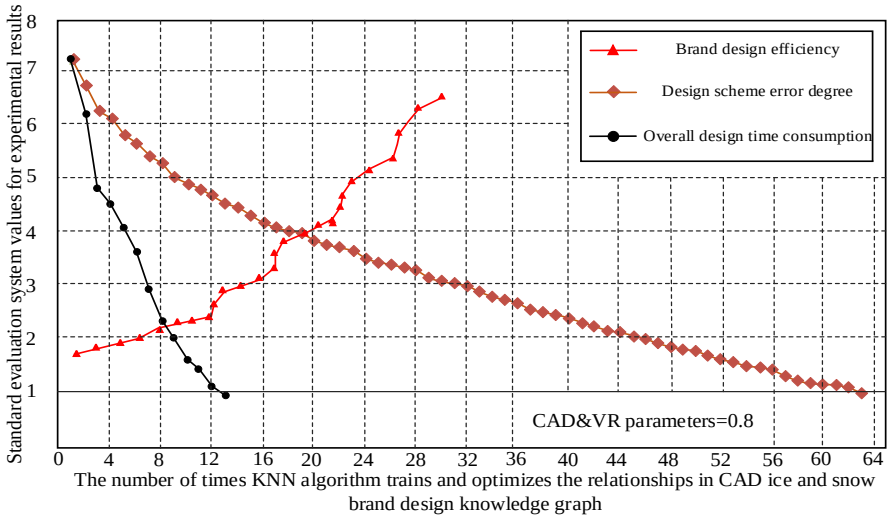

Figure 6: Validation of experimental results of CAD winter sports industry brand design and virtual reality co-creation platform integrating knowledge graph.

4.2 Analysis of Experimental Results

In order to further verify the universality and objectivity of the experimental data of the co-creation platform of CAD winter sports industry brand design and virtual reality based on a knowledge map, this study also uses a variety of different result analysis methods to quantify the experimental results and uses different weight evaluation functions to achieve the objective evaluation of the experimental results; the results are shown in Figure 7.

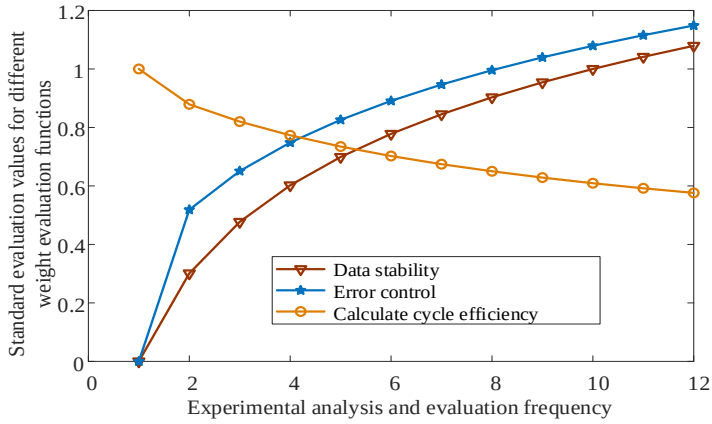

Figure 7: Confirmatory experimental results analysis of CAD winter sports industry brand design and virtual reality co-creation platform integrating knowledge graph.

It can be seen from Figure 7 that the experimental results of the co-creation platform of CAD winter sports industry brand design and virtual reality integrated with knowledge map have good quantitative results in terms of data stability, error degree control, and computational cycle efficiency. When the number of cycles reaches 10, the evaluation value corresponding to data

stability can reach 1, the evaluation value corresponding to error degree control can reach 1.5, and the evaluation value corresponding to computational cycle efficiency can be stabilized to about 0.7. This is because the entities in the CAD winter sports industry brand design knowledge map can be trained and optimized by using the KNN algorithm, and the results obtained are more stable. Therefore, the computational efficiency of the co-creation platform can be improved to a certain extent. In addition, after using different weight evaluation functions to evaluate the experimental results, it is found that the accuracy of the co-creation platform in the operation process is higher, and when using the weight evaluation function for dynamic changes, the accuracy of the co-creation platform in the operation process is also higher, which also shows that the platform can effectively and high quality complete the design tasks in a certain range.

5 CONCLUSIONS

Based on knowledge mapping and virtual reality technology, it is of great significance to explore the co-creation platform of CAD winter sports industry brand design and virtual reality for the development of the winter sports industry. This paper constructs a co-creation platform of CAD winter sports industry brand design and virtual reality through knowledge map technology and studies the construction of a knowledge map, the construction of a virtual reality scene, and the development of a CO creation platform. Firstly, the co-creation platform of CAD winter sports industry brand design and virtual reality was established, and the concept of winter sports industry brand design was transformed into visual graphic expression through the methods of knowledge map construction and scene construction; Secondly, the co-creation platform of CAD winter sports industry brand design and virtual reality is combined with knowledge map, and the co-creation platform of CAD winter sports industry brand design and virtual reality is developed through information retrieval, knowledge reasoning and other methods; Finally, the practicability and synergy of the co-creation platform of CAD winter sports industry brand design and virtual reality based on knowledge mapping and virtual reality technology were verified by experiments, and the further research direction was put forward. The experimental results show that knowledge mapping technology can effectively solve the uncertainty problem in the design process, so as to improve the efficiency and quality of winter sports industry brand design. This paper is only a method based on the existing research, and further research is needed in more fields in the future.

6 ACKNOWLEDGEMENT

Jilin Provincial Department of Education 2024 Social Science Research Program Key Projects, Research on brand image shaping and promotion of Jilin Winter sports industry in the context of digitalization (NO.JJKH20241206SK).

Liang Xu, https://orcid.org/0009-0000-1295-6673
Shiyong Hu, https://orcid.org/0009-0001-5121-0417

REFERENCES

[1] Arrighi, P.-A.; Mougenot, C.: Towards user empowerment in product design: a mixed reality tool for interactive virtual prototyping, Journal of Intelligent Manufacturing, 30(2), 2019, 743-754. https://doi.org/10.1007/s10845-016-1276-0

[2] Bu, L.; Chen, C.-H.; Ng, K.-K.; Zheng, P.; Dong, G.; Liu, H.: A user-centric design approach for smart product-service systems using virtual reality: A case study, Journal of Cleaner Production, 280(1), 2021, 124413. https://doi.org/10.1016/j.jclepro.2020.124413

[3] Chen, Y.-H.; Kara, L.-B.; Cagan, J.: BIGNet: A Deep Learning Architecture for Brand Recognition with Geometry-Based Explainability, Journal of Mechanical Design, 146(5), 2024, 051701. https://doi.org/10.1115/1.4063760

[4] Cui, H.; Peng, T.; Han, R.; Han, J.; Liu, L.: Path-based multi-hop reasoning over knowledge graph for answering questions via adversarial reinforcement learning, Knowledge-Based Systems, 276(1), 2023, 110760. https://doi.org/10.1016/j.knosys.2023.110760
[5] Dong, M.; Zeng, X.; Koehl, L.; Zhang, J.: An interactive knowledge-based recommender system for fashion product design in the big data environment, Information Sciences, 540(1), 2020, 469-488. https://doi.org/10.1016/j.ins.2020.05.094
[6] Du, H.; Zhang, X.; Wang, M.; Chen, Y.; Ji, D.; Ma, J.; Wang, H.: A contrastive framework for enhancing Knowledge Graph Question Answering: Alleviating exposure bias, Knowledge-Based Systems, 280(1), 2023, 110996. https://doi.org/10.1016/j.knosys.2023.110996
[7] Dzyabura, D.; Peres, R.: Visual elicitation of brand perception, Journal of Marketing, 85(4), 2021, 44-66. https://doi.org/10.1177/002224292199666
[8] Haruna, A.; Yang, M.; Jiang, P.; Ren, H.: Collaborative task of entity and relation recognition for developing a knowledge graph to support knowledge reasoning for design for additive manufacturing, Advanced Engineering Informatics, 60(1), 2024, 102364. https://doi.org/10.1016/j.aei.2024.102364
[9] Kuo, C.-C.-J.; Zhang, M.; Li, S.; Duan, J.; Chen, Y.: Interpretable convolutional neural networks via feedforward design, Journal of Visual Communication and Image Representation, 60(1), 2019, 346-359. https://doi.org/10.1016/j.jvcir.2019.03.010
[10] Lampropoulos, G.; Keramopoulos, E.; Diamantaras, K.: Enhancing the functionality of augmented reality using deep learning, semantic web and knowledge graphs: A review, Visual Informatics, 4(1), 2020, 32-42. https://doi.org/10.1016/j.visinf.2020.01.001
[11] Liu, Y.; Gu, F.; Wu, Y.; Gu, X.; Guo, J.: A metrics-based meta-learning model with meta-pretraining for industrial knowledge graph construction, Computers in Industry, 143(2), 2022, 103753. https://doi.org/10.1016/j.compind.2022.103753
[12] Ma, J.; Zhou, C.; Wang, Y.; Guo, Y.; Hu, G.; Qiao, Y.; Wang, Y.: PTrustE: A high-accuracy knowledge graph noise detection method based on path trustworthiness and triple embedding, Knowledge-Based Systems, 256(1), 2022, 109688. https://doi.org/10.1016/j.knosys.2022.109688
[13] Malik, A.-A.; Masood, T.; Bilberg, A.: Virtual reality in manufacturing: immersive and collaborative artificial-reality in design of human-robot workspace, International Journal of Computer Integrated Manufacturing, 33(1), 2020, 22-37. https://doi.org/10.1080/0951192X.2019.1690685
[14] Marques, B.; Silva, S.; Alves, J.; Araujo, T.; Dias, P.; Santos, B.-S.: A conceptual model and taxonomy for collaborative augmented reality, IEEE Transactions on Visualization and Computer Graphics, 28(12), 2021, 5113-5133. https://doi.org/10.1109/TVCG.2021.3101545
[15] Xie, C.; Yu, B.; Zeng, Z.; Yang, Y.; Liu, Q.: Multilayer internet-of-things middleware based on knowledge graph, IEEE Internet of Things Journal, 8(4), 2020, 2635-2648. https://doi.org/10.1109/JIOT.2020.3019707
[16] Zhao, M.; Huang, X.; Zhu, L.; Sang, J.; Yu, J.: Knowledge graph-enhanced sampling for conversational recommendation system, IEEE Transactions on Knowledge and Data Engineering, 2023(10), 2023, 35. https://doi.org/10.1109/TKDE.2022.3185154