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Computer-Aided Design and Applications

Optimization Strategy of Cultural IP and CAD Collaborative Design Based on Multi-Intelligent System

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Abstract. The multi-intelligent system can be applied to the creative generation of cultural IPs, helping designers better understand the target audience, grasp market trends, and design more attractive cultural products. Meanwhile, by integrating with CAD collaborative design systems, rapid implementation and iteration of design ideas can be achieved, enhancing the practicality and market competitiveness of the design. The design of cultural IP can help enterprises improve their competitiveness in the market and increase the trust and emotion between them and consumers. At the same time, the design of cultural IP has to meet the needs of enterprises and the emotional needs of consumers, so it needs to be communicated by multiple participants to achieve the final design effect. Previous design approaches are mostly centred on the designer, who communicates with different participants, which is time-consuming and inefficient. Therefore, this paper constructs a cultural IP and collaborative design (Co-design) optimization model based on a multi-intelligent system through a deep reinforcement learning algorithm and multi-agent cultural algorithm. The experimental results show that the model combines deep reinforcement learning, attention mechanism, and weighted computation to effectively improve the information fusion and graph information interaction performance among the intelligences, ensuring the efficiency and accuracy of participants' information interaction. In addition, the multi-agent cultural algorithm realizes the CAD collaborative purpose, improves the model convergence speed, shortens the waiting time of the participants, enhances the design efficiency, and the majority of the participants recognize the cultural IP design.

Keywords: Multi-Intelligent Systems; Cultural IP; CAD Collaboration; Design Optimization
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1 INTRODUCTION

With the economic and social development, the fiercely competitive market puts forward higher requirements for the commercial development of products, and consumers are no longer satisfied

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only with the serious homogenization of commodities it is more important to an enterprise, a product in maintaining the quality of the basis of the cultural connotation shown. Cultural IP is a kind of intellectual property with both cultural and market value that can inherit cultural products, phenomena, and images, which can integrate elements such as story, culture, character, and brand connotation. At the same time, the development of the cultural economy has raised people's awareness of and attention to intellectual property rights, and more and more businessmen have begun to create recognizable and personalized cultural IPs for their industries. In recent years, with the deepening of research on this theory by Chinese scholars, it has also begun to be widely applied in the field of education. Chen et al. [1] placed deep learning in the process of Chinese language teaching, which has important significance for both the teacher's teaching and the student's learning. After consulting literature and books, it is found that the application of deep learning theory in the Chinese language discipline mostly focuses on the development of overall teaching strategies or the application of reading and writing. The concept of "Chinese language learning task group" is rarely mentioned. It selected one of the 18 task groups, the "Classic Study of Chinese Traditional Culture" task group, guided by deep learning theory, to enrich the theoretical basis of teaching in this task group. This provides teachers with a new teaching perspective, allowing them to think about the teaching of the "Classic Study of Chinese Traditional Culture" task group from the perspective of deep learning. It has changed the traditional teaching mode and strategy and made some contributions to the research of deep learning and the "Classic Study of Chinese Traditional Culture" task group to a certain extent. With the arrival of the new media era, coupled with the continuous upgrading and iteration of Internet technologies such as big data and cloud computing, many new media platforms emerge endlessly, and museum culture and innovation gradually embark on the path of digital development. Chen et al. [2] analyzed the intelligent adjustment and optimization of cultural and creative product models under multimedia intelligent systems. At present, many cultural and creative products have chosen to keep up with the trends of the times and continuously explore the path of integrating new media platforms and cultural resources for development. The cultural and creative industry has thus ushered in new development opportunities and many challenges. However, from the perspective of business management in recent years, apart from leading museum cultural and creative brands represented by the Palace Museum, the development momentum is good. Most cultural and creative products in museums in China still face many development pain points, such as insufficient creativity, lack of personalized features, and single promotion methods. Therefore, how to develop high-quality museum cultural and creative products that are loved by consumers and promote positive consumer behaviour such as purchasing is a key issue that the museum cultural and creative industry urgently needs to solve.

Chung and Huang [3] analyzed the ink boundary enhancement adversarial network of digital abstract images. Since 2000, a new generation of animation creators has developed digital ink painting, 2D digital ink animation, and 3D ink animation using computer software such as Photoshop, Flash, Maya, and 3DS Max. He has created some 3D ink animation works. Some of these works have also won awards in multiple domestic and international competitions. In these 3D animation works, a visual style similar to traditional ink-and-wash animation is presented, creating a virtual world of ink-and-wash. It utilizes the powerful expressive power of computer 3D technology, combined with post-production special effects and synthesis software to create changes in ink depth and reality, making 3D ink animation also have the unique charm of traditional Chinese ink painting. 3D ink animation presents a richer audio-visual language than traditional ink animation. Cultural IP is an important part of modern commercial culture, which gives products cultural attributes, shows strong cash penetration on the basis of commercial value, and is a cultural symbol for the long-term development of an enterprise. Multicultural wallpaper design is often limited by the limitations of designers' personal aesthetics and manual drawing, which makes it difficult to meet the diversified needs of consumers. To solve this problem, Gao et al. [4] analyzed the texture generation and style transformation of multicultural wallpaper with multi-label semantics. Using deep learning and image processing algorithms, it can extract rich texture features from a large number of wallpaper samples. These features can be organized into a set of labels, and each label represents a specific texture or style. When users select the tags they are interested in, the algorithm will combine these tags to

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generate a wallpaper texture that meets the requirements. The design of cultural IP needs to organically combine commercial attributes and cultural elements, forming a corresponding cultural IP ecosystem centred on it, promoting the progress of IP creation, operation, derivatives development, profit promotion and other links, and attracting more consumers in the competitive market. Under the tide of digitalization and intelligence, the field of culture and art is undergoing a profound change. As a cutting-edge technology in the field of artificial intelligence, multi-agent systems have brought a new perspective and paradigm to the creation of painting culture. Guo et al. [5] analyzed multi-agent systems through man-machine cooperation. It not only widens the boundary of painting creation but also enriches the connotation of the cultural and artistic universe. In the field of painting culture creation, a multi-agent system can realize the painting creation process of man-machine cooperation through in-depth cooperation with artists. This paradigm not only breaks through the limitations of traditional painting but also provides artists with more creative possibilities and sources of inspiration. Therefore the quality and efficiency of cultural IP design is an important prerequisite for enterprises to promote cultural IP.

CAD is one of the most commonly used design tools in the design field, and in the previous cultural IP design designers often completed the design independently based on the enterprise's needs and relevant information, which has high requirements for the communication ability between the designer and the enterprise as well as the designer's personal design experience, and needs to consume a large amount of time and cost. In the field of digital art, image style conversion has always been a research direction of great concern. With the continuous development of deep learning technology, the art and culture image style conversion method based on the generation of antagonistic networks by deep extraction has gradually emerged, providing a new creative tool for artists and designers. Han et al. [6] used the generative adversary network to fuse these features and generate images with specific artistic styles. This method not only retains the content information of the original image but also successfully integrates the artistic style into the generated image, realizing the perfect combination of style and content. With the development of computer technology and artificial intelligence technology, some researchers have introduced rule engines, knowledge systems, and neural network and machine learning algorithms in the design field, which has improved the efficiency of the application of artificial intelligence in the design field. As an important carrier of inheriting and carrying forward the history and culture, the application of CAD technology in the design and optimization of Museum Cultural and creative products is of great significance to improve product quality and meet the needs of consumers. Huang et al. [7] discussed the online text review under the CAD collaborative design optimization strategy and then analyzed consumers' cognition of Museum Cultural and creative products. The CAD collaborative design optimization strategy emphasizes that in the process of product design, through the cooperation of multiple departments and fields, the sharing and integration of design resources can be realized, and design efficiency and quality can be improved. In the design of cultural and creative products in museums, CAD technology can help designers more accurately grasp the elements of product form, size, material, and so on, as well as combine historical and cultural elements to create cultural and creative products with unique charm. However, the design process still requires continuous design communication between designers and enterprises. If there is an IP joint situation in the design of cultural IP, the design requirements that designers have to face will increase several times. They need to continuously extract the required contents from the massive information and data. Museums, as important places for protecting and inheriting historical and cultural heritage, contain rich cultural IP resources within them. These cultural IPs not only include precious cultural relics, artworks, and historical sites but also cover related stories, legends, and cultural connotations. However, traditional display methods are often limited by space and form, making it difficult to showcase the charm and value of cultural IP fully. The introduction of virtual reality and mixed media technology has brought revolutionary changes to the display and dissemination of cultural IP within museums.

Digital museum cultural consumption is not only an upgrade of information consumption but can also be seen as a participatory ritual consumption. Pietroni [8] analyzed the collaborative design of audience cultural IP and intelligent agents in digital museums. From the perspective of communication ritual, the consumption behaviour of digital museums can be generalized as cultural

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consumption behaviour conducted through digital exhibitions, digital collections, and other experiential forms on digital museum platforms. Digital museum cultural consumption is carried out in interactive and immersive experiential consumption scenarios, usually with a specific theme as the main thread, guiding consumers to engage in participatory cultural exploration through interactive means. At the same time, as participants in cultural consumption behaviour, digital museum visitors need to follow the principle of being people-oriented in product development and experience design, which is in line with the social orientation of contemporary museums. Based on the theoretical overview and analysis of the redesign of Dunhuang graphic elements in tourism souvenirs from an experiential perspective in the previous text, Su et al. [9] verified the complementary relationship between the experiential perspective and tourism souvenirs by analyzing relevant cases of redesign in tourism souvenirs from an experiential perspective and analyzing the current situation of tourism souvenirs. The possibility of redesigning Dunhuang graphic elements in tourism souvenirs from an experiential perspective was analyzed and explored. Through virtual reality technology, designers can delve deeper into Dunhuang art, extract its essence and characteristics, integrate them into modern cultural IP design, and create cultural products that not only have traditional charm but also meet modern aesthetic needs. In this process, there are relationships such as cooperation, competition, and bonding between intelligences, and mutual decision-making interacts with each other. Based on this concept, this paper constructs a CAD collaborative virtual ecosystem through the AGENT culture algorithm, combined with deep reinforcement learning to realize the purpose of cultural IP design for multi-intelligent systems.

The innovations of this paper are as follows:

First of all, this paper constructs a CAD collaborative virtual environment through an agent culture algorithm to realize multiple CAD users connecting, interacting and information sharing and synchronization so that different subjects in the design process participate in cultural IP design together.

Secondly, this paper introduces an attention mechanism and a simplified weighted graph information enhancement algorithm in a deep reinforcement learning multi-intelligence system, which improves the effectiveness and decision-making of the system's observation and fusion of information.

2 RELATED WORK

With the vigorous development of digital art and cultural and creative industries, art style transformation has become an important means for designers and artists to pursue innovation and differentiation. Traditional style conversion methods are often limited by a single algorithm and fixed conversion mode, which makes it difficult to meet diverse needs. Wang et al. [10] proposed a reversible art and culture IP style conversion method based on a multi-agent system network, aiming to achieve more flexible, efficient and personalized style conversion. The reversible art and culture IP style conversion method uses the characteristics of the multi-agent system network and takes different art styles and cultural elements as the input of the agent. Through the information interaction and collaborative work between agents, the transformation and fusion of styles are realized.

Multi-agent system (MAS) has been widely used in cultural and creative industries. Especially in the field of marine cultural creative product design, MAS provides designers with new design ideas and methods with unique advantages. Wang [11] discussed the construction and deconstruction process of marine cultural creative product design methods based on MAS. MAS integrates various creative generation algorithms and combines the cultural characteristics of the South Island aborigines to provide designers with rich creative sources. At the same time, the agent can also screen and evaluate the generated ideas according to the design objectives and constraints to ensure the innovation and practicability of the final design. Through the in-depth study of Aboriginal products in South Island, we can extract their unique cultural elements, such as patterns, colours, materials, etc. Then, using the intelligent processing ability of MAS, these elements are transformed into the

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modern design language, which not only retains the original cultural charm but also meets modern aesthetic needs. The traditional way of displaying historical and cultural creative products is often limited to physical displays and textual explanations, making it difficult to fully showcase the cultural connotations and characteristics of the products. AR technology provides a new perspective and way to showcase historical, cultural, and creative products by overlaying virtual information in the real world. Through AR technology, consumers can have a more intuitive understanding of the historical background, manufacturing process, and cultural connotations of products, thereby obtaining a richer sensory experience. Xu et al. [12] explored the impact of augmented reality-based product display on consumer product evaluation.

Xu et al. [13] used deep learning to recognize and transform reinforced classical Chinese into modern literary styles. It utilizes a text-style model of reinforcement learning to construct a unique cultural experience for design creativity. Secondly, deep learning is a type of learning that emphasizes integration and transfer. The "integration" here emphasizes the integration of teaching content and student experience, including the integration of students' own experiences and non-learned experiences. In previous teaching and learning, in order to enable students to understand the knowledge they have learned to the greatest extent possible, teachers have always tended to adopt a single-text teaching mode, explaining the knowledge points by "breaking them apart" and "crushing them". Such teaching can certainly help students learn, but in the long run, it is detrimental to the establishment of the overall knowledge framework and structure of students. Students already have some experience in daily life, so in the teaching process, teachers should not only focus on the current knowledge to be taught but also pay attention to the knowledge that students already have. Using previous experiences as a framework to construct and integrate new knowledge, in order to help students achieve deep learning. Based on the research on cultural and creative IPs, Zhang [14] introduced the perceived value of new media scenarios and divided the consumer perceived value of museum cultural and creative products into seven research dimensions. They are perceived functional value, perceived aesthetic value, perceived new media scene value, and perceived cost. In addition, combining the behavioural characteristics of consumers in the era of new media with consumer decision-making models, measuring consumer behaviour willingness from two perspectives: purchase intention and willingness to integrate new media. It has constructed a research model that conforms to the development characteristics of the new media era and proposes research hypotheses on the impact of consumer perceived value of museum cultural and creative products on consumer behaviour willingness. Using SPSS 26.0 and AMOS 24.0 data analysis software, descriptive statistical analysis, consumer individual difference analysis, reliability and validity analysis, normality test, and other empirical analyses were conducted on the survey data to verify the proposed hypotheses.

Within the framework of the theory of ritual communication and the new museum theory, digital museums are seen as a socially significant practical approach. Especially with the continuous advancement of digital technology, the social significance practice of digital museums has become more perfect. Through technology empowerment culture, digital museums, driven by Internet technology, have opened up new development paths for the cultural industry and become a form of online exhibition and interactive cultural industry [15]. The multi-agent system can design a variety of interactive forms so that the audience can have a deeper understanding of the story and cultural connotation behind the cultural relics and improve the audience's sense of participation and experience. Zhong and Huang [16] proposed a cultural IP-style system for CAD collaborative design based on an improved convolutional neural network (CNN) algorithm. The system combines the advantages of deep learning and CAD technology, realizes the intelligent extraction of design elements, style conversion, and collaborative design, and provides a new innovation tool for the cultural and creative industry. The traditional CAD system mainly focuses on geometric modelling and engineering design and lacks the ability to convert the cultural IP style. The CAD collaborative design cultural IP style system based on the improved CNN algorithm learns a large number of cultural IP data through the deep learning model and extracts the characteristic information of different styles. This feature information includes design elements such as lines, colours, and textures, which can accurately reflect the style characteristics of cultural IP. Totem culture, as an

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important part of human civilization, has rich cultural connotations and artistic value. Zifei et al. [17] discussed the application of totem culture elements based on the multi-agent system in Jinqu cultural and creative product design. It aims to explore the deep meaning of totem culture and provide new ideas and ideas for cultural and creative product design. In the field of cultural and creative product design, MAS can make full use of its ability of independent decision-making, learning and communication to realize the intelligent analysis and creative generation of totem cultural elements. At the same time, MAS can also adjust and optimize the design scheme in real-time according to the market demand and user feedback, so as to improve the pertinence and practicability of the design.

3 OPTIMIZATION MODEL CONSTRUCTION OF CULTURAL IP AND CAD CO-DESIGN BASED ON MULTI-INTELLIGENT SYSTEM

3.1 Theory of Cultural IP Design Based on Emotionalization

The purpose of cultural IP design is to improve the enterprise's visualization, attract consumers' attention, and get consumers' human recognition. This paper aims to realize the design of cultural IP based on the theory of emotionalization. Emotion is one of the important ways of resonance between human beings, and emotion is an embodiment of the complex physiological and psychological changes of human beings. In life, emotion can not only express consumers' inner real emotional experience of different things but also reflect consumers' spiritual values, which can make the design goal and consumers' inner resonance. Therefore, cultural IP design based on emotionalization incorporates emotions and feelings that can resonate with consumers' psychology in the design process and convey the values to be expressed by the IP design from physiological, emotional, and psychological aspects. In this design concept, cultural IP design should meet the emotional needs of consumers at three levels, the first being the instinctive level, which is to make emotional design language for the colour, material, and shape of the product to meet the basic emotional experience of consumers to achieve the purpose of influencing consumers so that consumers have an intuitive and instinctive emotional mapping of the product. The second is the behavioural level, in which the focus of product design is shifted to its own function, structure, and interaction, and consumers can get emotional satisfaction and care in the process of using the product to enhance the interaction between consumers and products. The third is the reflection level, which pays more attention to the intention of the cultural IP and the emotional story behind it so that consumers can obtain personalized needs from the cultural IP, enhance the emotional experience to trigger resonance, and then have a higher degree of satisfaction and recognition of the product.

The purpose of cultural IP design is to make enterprises have more distinctive, personalized, and storytelling cultural logo symbols in the competitive market, so as to enhance the resonance between enterprises and consumers, increase the emotionality between the two, get more consumer recognition, and enhance the credibility and competitiveness of enterprises in the market. Therefore, cultural IP design should not only meet the psychological and emotional needs of consumers and establish an emotional bridge between enterprises and consumers but also bring aesthetic enjoyment of spiritual pleasure and satisfaction to consumers through the design of beauty and artistry, which is a unique experience in itself and is a special emotional construction process for consumers. There are differences in different consumers' own life experiences, religious beliefs, education, and upbringing, and the complexity, diversity, and differences in consumers' psychological needs should be fully considered in the emotional design of cultural IP, to understand consumers' emotional elements and empathy elements. At the same time, the cultural IP should be in line with the development and needs of its own enterprise and should understand the consumer's impression of the enterprise before designing so as to avoid the problems of the large gap between the IP design and the consumer's impression, single design, and lack of symbolism, etc., and to leave enough space for the subsequent derivation and secondary creation of the cultural IP. As shown in Figure 1, the flow diagram of the cultural IP emotional design method is shown.

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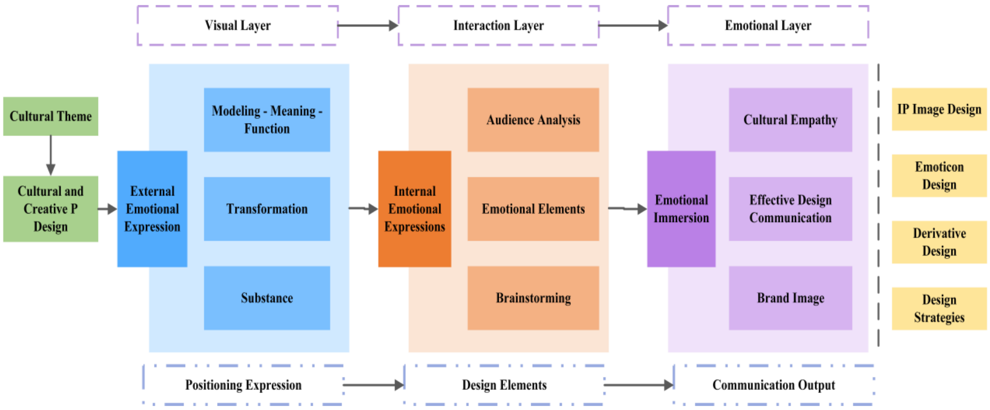

Figure 1: Schematic flow diagram of cultural IP emotional design methodology.

3.2 CAD Co-Design Optimization Model Based on Multi-Intelligent System

In a multi-intelligence system, there are multiple relatively independent intelligences, each of which can independently complete the corresponding tasks, realize information sharing and decision-making among each other, and face the problem challenges together. Reinforcement learning, one of the paradigms in machine learning, has the advantages of real-time trial-and-error interaction and long-term decision-making planning by virtue of its strong flexibility and autonomous learning, which can help different intelligences realize the construction of a multi-intelligence system. In the process of the multi-intelligence system, there are problems such as low utilization of environment leading to the negative impact of collaborative decision-making of intelligence, and unstable connection relationship between intelligence, etc. Therefore, this paper introduces the attention mechanism and graph neural network in the multi-intelligence system to improve the performance of information fusion of multi-intelligence systems.

Compared with single intelligences, multi-intelligence systems require multiple intelligent subjects to jointly influence the state of the environment under the same environmental conditions, which requires reinforcement learning to be able to unite the actions of multiple intelligences and observe the relevant states of each intelligence. At the same time, the decision-making of multiple intelligences has an interactive effect, which improves the overall instability of the environment and requires the reinforcement learning model to be extended. Expanded multi-intelligence reinforcement can be in accordance with the centralized learning distribution of information fusion and strategy between multiple intelligences, the model of multiple intelligences can be in the execution of the action phase only according to their own observation information to complete independent action, that is, the cultural IP design process each intelligent can be based on specific needs to complete the corresponding task objectives. The difference with the traditional distribution is that this mode will maintain the Critic network of the existing intelligent information during training, so as to achieve the purpose of better integration of global information, so that the decision-making and evaluation information is more accurate, and each intelligent is guided by more accurate decision-making and evaluation of the Actor network of the signal error is smaller. In this paper, we use MADDPG with Actor-Critic architecture to realize the maintenance of the actor-network of each intelligence and its deterministic strategy gradient formula is shown in (1):

$$\nabla_{\varphi_n} T(\mu_n) = E_{o,a\sim D}\left[\nabla_{\varphi_n} \mu_n(a_n | o_n) \nabla_{a_n} Q_n^{\mu}(o, a_1, \ldots, a_i)\Big|_{a_m=\mu_m(o_m)}\right] \tag{1}$$

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The observation vector of all the intelligence in Eq. is denoted as $o = \{o_1, o_2, ..., o_i\}$, and the corresponding centralized state-action value function of the intelligence with sequence number n is denoted as $Q_n^{\mu}(o, a_1, ..., a_i)$, which is updated as shown in Eq. (2):

$$T_{Q_n}(\theta_n) = E_{o,a,\tau_n,o'}\left[(Q_n^{\mu}(x, a_1, ..., a_i) - y_n)^2\right] \tag{2}$$

In Eq. the valuation of the target network is denoted as $y_n = \tau_n + \gamma Q_n^{\mu'(\varphi^-)}(o', a_1', ..., a_i')\big|_{a_m' = \mu_m'(o_m)}$, and the corresponding update parameter target strategy network is denoted as $\mu'(\varphi^-)$, which has a lag.

Based on the value decomposition when the fight can be maintained over a centralized joint state-action value function, the criterion that needs to be satisfied is shown in Equation (3):

$$\arg\max_a Q_{tot}(\tau, a) = \begin{pmatrix} \arg\max_{a_1} Q_1(\tau_1, a_1) \\ \vdots \\ \arg\max_{a_i} Q_i(\tau_i, a_i) \end{pmatrix} \tag{3}$$

The above criterion can guarantee the consistency between the optimal joint action and the optimal individual action, and the joint value function is trained and updated in the form shown in Eq. (4):

$$\begin{aligned} Q_{tot}(s, a) &= \tau + \gamma \max_{a'} Q_{tot}(s', a') \\ &= \tau + \gamma \max_{a'} \mathrm{M}(Q_1(\tau_1, a_1), .., Q_i(\tau_i, a_i); s') \end{aligned} \tag{4}$$

The corresponding hybrid network decomposed into the above values in Eq. is denoted as $\mathrm{M}\ \cdot$.

There is a problem of graph information fusion in the design composition of cultural IP, which is carried out in this paper by using a graph neural network, and the neighbour matrix of GCN completes the convolution operation on the connected nodes according to Eq. (5):

$$H^{l+1} = \sigma(PH^l W^l) \tag{5}$$

In the formula, the activation function is $\sigma(\cdot)$, the normalized adjacency matrix is denoted as P , the computed features with sequence number l are denoted as H^l , and the parameter matrix to be learned is denoted as W .

The input vectors $X = \{x_1, x_2, ..., x_i\}$ can be mapped to the vectors in the Q, K, V matrix by a linear neural network and the attention matrix between the first two matrices is shown in Equation (6):

$$A = soft\max(\frac{QK^T}{\sqrt{d}}) \tag{6}$$

The formula for weighting the input feature vectors for multi-intelligent reinforcement learning is shown in (7):

$$w_k = \frac{\exp(f(\Omega, e_k))}{\sum_{n=1}^{K} \exp(f(\Omega, e_n))} \tag{7}$$

The smart feature vector with sequence number k in Eq. is denoted as e_k , the corresponding importance weight is denoted as w_k , the current smart feature vector is denoted as Ω , and the observation value is denoted as o .

A schematic diagram of the actions of the multi-intelligence system is shown in Figure 2.

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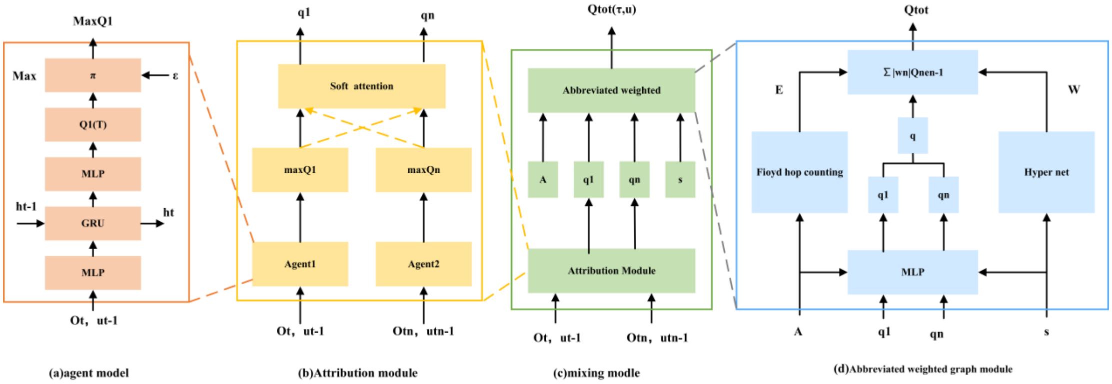

Figure 2: Schematic diagram of multi-intelligent system action.

Cultural IP needs to complete the purpose of multi-party collaboration and multi-party participation in design under CAD collaboration again; this paper adopts a multi-agent cultural algorithm to realize the goal of multi-CAD collaborative design. Let the corresponding preference set of users with the number of M be denoted as $\{P_1, P_2, ..., P_M\}$, and h is randomly selected as the initial clustering centre among all user preferences, denoted as $C_i(0), i = 1, ..., h$. Let the coding length be denoted as G, as shown in Eqs. (8) and (9):

$$S_j^i = \frac{1}{G}\sum_{h=1}^{G}\delta_h(P_{jh}, C_{ih}) \tag{8}$$

$$\delta_h(P_{jh}, C_{ih}) = \begin{cases} 1, P_{jh} = C_{ih} \\ 0, P_{jh} \neq C_{ih} \end{cases} \tag{9}$$

If the participant a sequence number j and C_i has the closest clustering center it will be classified into the corresponding blue dream. According to the result of mutual pollination, different alliance clustering centres can be dynamically adjusted, denoted as $C_i(t) = (C_{i1}(t),\ C_{i2}(t), \ldots, C_{iG}(t))$, as shown in Equation (10):

$$C_{il}(t) = \begin{cases} P_{jh}, \exists P_{jh} \neq * & \max(\bar{N}(P_{jh})) \\ *, \forall P_{jh} = * & j = 1, 2, ..., |C_i| \end{cases} \tag{10}$$

The gene pattern of the locus with sequence number h has the most alleles among the total preference knowledge contained in the formula. $\bar{N}(P_{jh})$

In order to ensure that the number of participants involved in the coalition grouping is maximized, the average evaluation time of all participants selected for evaluation will become the coalition knowledge migration interval, denoted δ, as shown in Equation (11):

$$\delta = \left|\frac{1}{M}\sum_{n=1}^{M}T_n\right| + 1 \tag{11}$$

The structure of CAD collaborative cultural IP design based on a multi-agent cultural algorithm is shown in Figure 3.

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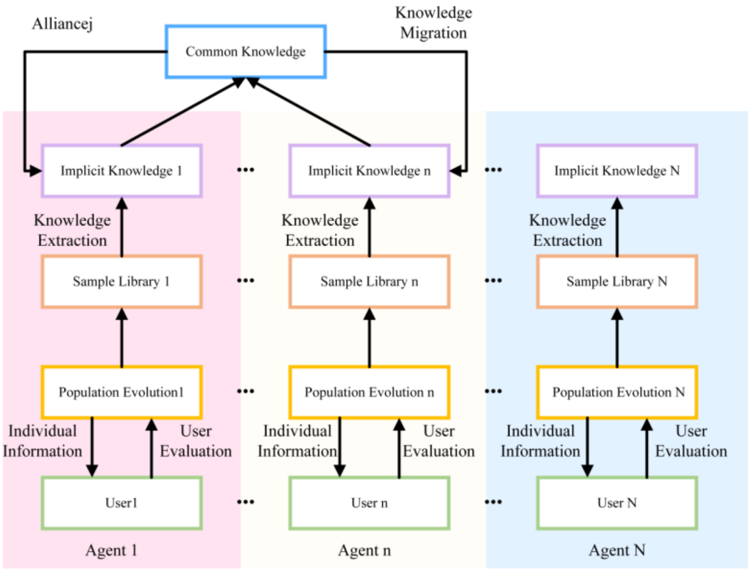

Figure 3: CAD collaborative cultural IP design structure based on a multi-agent cultural algorithm.

4 EXPERIMENTAL RESULTS OF CULTURAL IP AND CAD CO-DESIGN OPTIMIZATION MODEL BASED ON MULTI-INTELLIGENT SYSTEM

In order to validate the performance of the multi-intelligentsia system and to determine the parameter settings, this paper examines the performance of the collaborative strategy between intelligentsia through standard application scenarios. Experimentation of the system and other benchmark algorithms are trained in the same scenarios, in which the application scenarios atmosphere simple scenarios, difficult scenarios and super-difficult scenarios, to ensure that the multi-intelligent system can be used in different application scenarios to test the performance of the system, the results are shown in Figure 4. From the results in Fig. 4, it can be seen that overall the multi-intelligent system can be applied in different scenarios and the performance has been improved substantially, and the information fusion effect has been improved by about 25% compared with other benchmark algorithms, especially in Fig. (a) (b) (c). This indicates that both the attention mechanism and graph neural network introduced in the system can improve the system's collaboration strategy and realize information supplementation in application scenarios with different levels of complexity. However, the system's application performance improvement is not obvious in super difficult application scenarios.

In order to further verify the role of weighted computation, this paper removes the corresponding module in the above application scenarios and compares the results before and after the removal, which are shown in Figure 5. From the results in the figure, it can be seen that in application scenarios with different degrees of difficulty, the application effect of the multi-intelligent system with weighted computation removed is reduced to different degrees. In simple application scenarios, the application effect of the system after removal has a significant gap at the beginning and gradually stabilizes at the later stage, with little gap between them. However, in difficult and super-difficult application scenarios, the gap between the application effect of the removed multi-intelligence system to the later stage and the effect before removal increases significantly, and the more difficult the application scenario is, the more obvious the gap is. This shows that the cooperation of weighted computing and attention mechanism has a great influence on the information fusion and writing effect of multi-intelligent systems, and both of them can obviously improve the collaboration and interaction

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between each intelligence and provide a good information interaction foundation for the design of cultural IP.

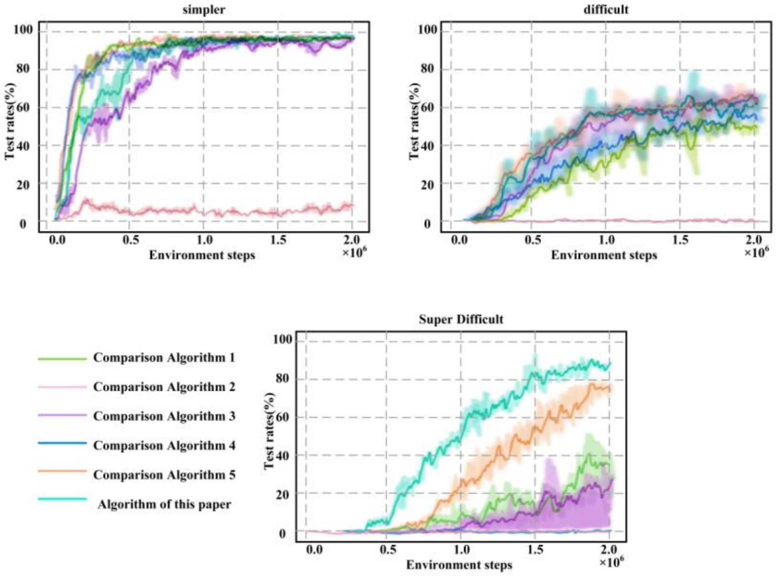

Figure 4: Performance effect of the multi-intelligent system in different application scenarios.

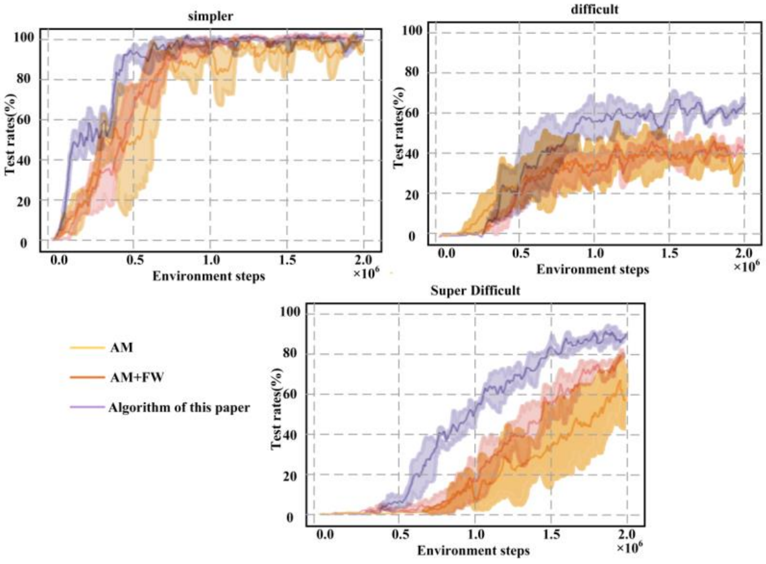

Figure 5: Comparison of the effect of weighted calculation of the role of multi-intelligent system.

Based on the multi-intelligent system CAD collaborative design optimization model applied in the cultural IP design aims to improve the efficiency, quality and interactivity of the design, in order to verify the performance of the model, this paper selected eleven participants through the CAD collaborative application of multi-intelligent system model for the design of cultural IP. In the

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experiment, each participant independently completed the corresponding design thought and evaluated the satisfaction level of the final result, as shown in Figure 6 for each participant's operation evolution time, generation and satisfaction level results. From the data in the figure, it can be seen that there is variability in the number of generations of evolution for different participants in the cultural IP design task weight, and there is a certain magnitude of disparity in the evolution time with the variability of the number of generations, but all the evolution time is within 7 seconds, which ensures the time efficiency. In addition, although the number of evolutionary generations varied from participant to participant the vast majority of participants were satisfied with the results of the cultural IP design evaluation. This suggests that the cultural IP and CAD co-design optimization model based on the multi-intelligent system can improve the interactivity of the participants, realize the optimization of the cultural IP design based on the suggestions of the participants, and improve the quality of the design.

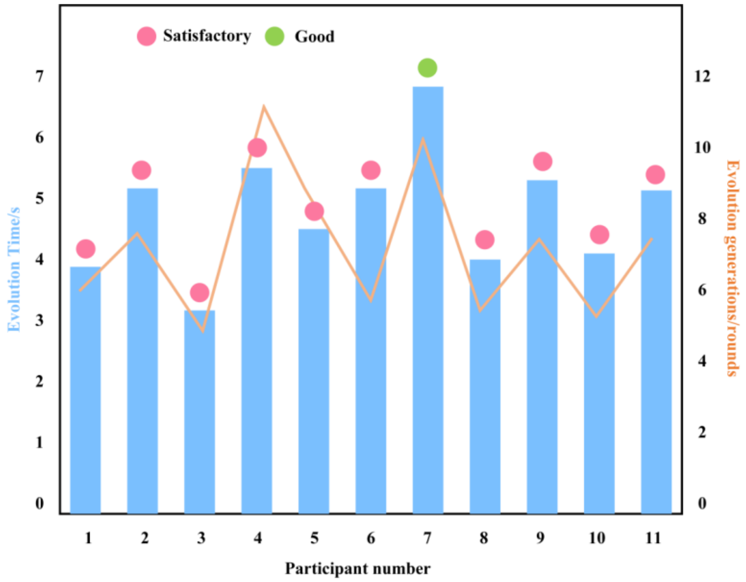

Figure 6: Results of participants' evaluation of the number of generations, time and satisfaction with the evolution of cultural IP design engagement.

In order to verify the efficiency of the cultural IP and CAD co-design optimization model based on a multi-intelligent system, two other algorithmic models are selected for performance comparison in this paper, and the results are shown in Figure 7. From the results in the figure, it can be seen that the average evolution generation of the model in this paper is lower than that of the other two algorithmic models and obviously improves the average evolution time. This shows that the model can shorten the evolutionary convergence time, complete the corresponding information fusion and interaction tasks in a short time, improve the efficiency of CAD collaboration, and reduce the waiting time of participants.

In summary, the optimization model of cultural IP and CAD co-design based on a multi-intelligent system can improve the efficiency and quality of information fusion and information interaction of cultural IP participants, adapt to application scenarios with different degrees of difficulty, and realize information supplementation. At the same time, it can improve the CAD co-design efficiency in cultural IP design, shorten the waiting time for interaction, improve the quality of cultural IP design, and gain the recognition of all participants.

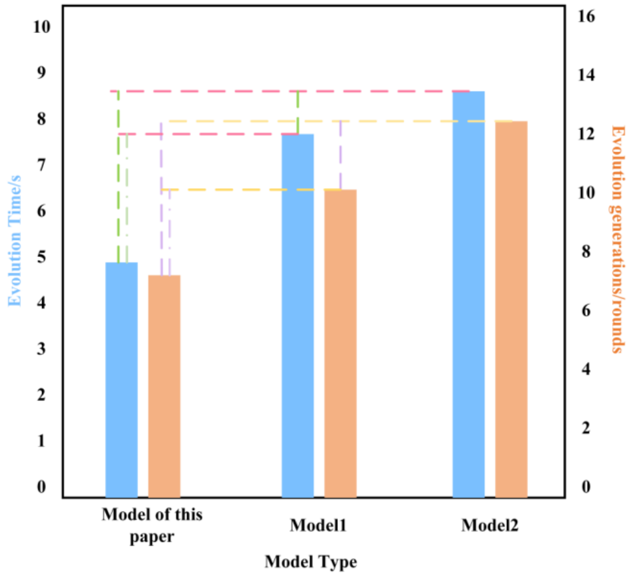

Figure 7: Performance comparison results of three algorithmic models.

5 CONCLUSIONS

Cultural IP design is an important component of enterprise development, which not only reflects the cultural connotation of the enterprise but also improves consumer trust and recognition of the enterprise and enhances the competitiveness of the enterprise in the market. In the past, CAD design mainly relied on continuous communication between participants to achieve the final design effect, with a large time cost and low communication efficiency. Therefore, this paper combines deep reinforcement learning and a multi-agent cultural algorithm to construct a cultural IP and CAD co-design optimization model based on a multi-intelligent system, which realizes the purpose of multi-intelligent to collaborate to complete the cultural IP design subtasks and strengthens the CAD collaborative efficiency by multi-agent cultural algorithm. The experimental results show that the combination of deep reinforcement algorithm, attention mechanism, and weighted computation in the cultural IP and CAD co-design optimization model based on a multi-intelligent system effectively improves the model information fusion and graph information processing ability, and interaction ability, improves the adaptability of the model in different difficult application scenarios, and ensures the validity and accuracy of the interaction data of different participants. In addition, the model realizes the purpose of multiple CAD co-design through the multi-agent algorithmic module, and compared with the other two algorithmic models, it shortens the convergence time of the model, improves the efficiency of the participants' design participation, and the different participants have a higher degree of satisfaction with the cultural IP design. Although the model in this paper improves the accuracy of application scenarios and the information fusion and interactivity between multiple intelligences, there are still areas that need to be further optimized in terms of cultural IP design efficiency. In addition, the limited research data in this paper has certain limitations, and it is necessary to increase the evaluation of consumer satisfaction with cultural IP and increase the dimension of design effect evaluation in the next study.

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