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Computer-Aided Design AND APPLICATIONS

Multimodal Fusion Technology in Art Decorative Pattern Design

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Abstract. With the improvement of modern science and technology, more and more artistic design elements and traditional decorative styles are integrated, and people's vision is also constantly expanding and improving their aesthetic ability. The audience has evolved from focusing on the feeling of Art Deco style to paying more attention to the combination of reality and abstract spirit. Therefore, decorative art patterns also have higher requirements. In this paper, with the help of multi-modal fusion technology, the reconstruction of art decorative patterns and the application of innovative design are studied. Firstly, the exploration process of multimodal theory in digital art is discussed, and the traditional decorative pattern style is combined to provide ideas for the future innovation direction. Multi-modal fusion technology is used to process the image fusion process, complete the task of image segmentation in different dimensions, and further improve the three-dimensional display effect of art decorative patterns. Finally, aiming at the integration of art decorative patterns and different product needs, we can realize the generation of innovative schemes under multi-modal perception and optimize the design of finished products by using color and graphic collocation. The research results show that the multi-modal fusion technology can show the diversified styles of Art decorative patterns so that the design works are more in line with the aesthetic needs of modern people.

Keywords: Multi-Modal Fusion; Art Decoration; Pattern Design; Image Segmentation; Innovative Style
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1 INTRODUCTION

Art Deco patterns are the display of culture and the epitome of historical life, and they are considered to be an important carrier for recording national cultural inheritance [1]. Chinese decorative patterns have a very long history, which can originate from the Neolithic period, from the painted pottery culture to a wide variety of patterned elements, which together constitute the evolution process of excellent traditional culture. With the gradual deepening of social and economic development and modern life, Chinese art decorative patterns have shown strong national cultural characteristics and have an irreplaceable position in the field of art design [2]. After entering the digital age, the design and application of decorative art patterns are important in this field. Modern scientific and

technological means not only provide opportunities for the innovation of art deco patterns but also add them to the digital competition process [3]. When exploring image retrieval in the field of art decoration patterns, content-based art decoration image retrieval (CBIR) systems have shown great potential [4]. It can accurately find artistic decorative patterns with similar styles and element matching in a large dataset by analyzing and querying key features in images. Art decorative patterns often attract attention with their unique texture design, so extracting texture features is crucial for CBIR systems [5]. Some scholars have proposed a CBIR system specifically designed for optimizing art decoration patterns, which cleverly integrates colour and texture feature analysis to achieve efficient recognition and retrieval of complex art decoration elements. In response to the rich and colourful characteristics of artistic decorative patterns, colour moments and colour histograms in RGB and HSV colour spaces are used to comprehensively capture the colour distribution characteristics of the image [6]. By combining these two colour spaces, we can more accurately describe the colour characteristics of artistic decorative patterns. RGB space directly reflects the original colour information of an image, while HSV space focuses more on the intuitive perception of colours, such as hue, saturation, and brightness, which is crucial for understanding the colour emotions and atmosphere of artistic decorative patterns [7]. Some scholars have adopted three methods: local discrete cosine transform (DCT), local grayscale co-occurrence matrix (GLCM), and local binary pattern (LBP) to depict the texture details of artistic decorative patterns from different perspectives. The CBIR system can significantly improve the precision and recall of artistic decoration pattern retrieval. Moreover, it demonstrates strong robustness and adaptability in dealing with complex and ever-changing artistic decorative elements and has significant advantages compared to existing methods [8].

Image stitching technology, especially in the field of artistic decorative patterns, has gradually gained widespread application in image registration algorithms. This needs to be combined with new sensing devices and deep learning technology to promote further development of art decoration image processing [9]. By optimizing image transmission protocols and compression algorithms, information loss in data transmission is reduced, ensuring that every detail of artistic decorative patterns can be accurately captured and transmitted to the processing end. Art decorative patterns often contain rich details, complex structures, and unique colours, which pose significant challenges in the process of remote splicing [10]. To address this issue, some scholars first analyzed the characteristics of artistic decorative patterns and designed targeted remote splicing methods. By re-dividing pixel regions and combining vector correlation coefficients to enhance the detection and description ability of feature points, the algorithm can more accurately capture key feature points in artistic decorative patterns. In the process of splicing art decorative patterns, the application of the RANSAC algorithm makes the alignment between images more accurate, reducing splicing errors caused by mismatches. They have innovatively improved the Scale Invariant Feature Transform (SIFT) algorithm to address the uniqueness of artistic decorative patterns. In order to further improve the accuracy of image stitching, the Random Sample Consistency (RANSAC) algorithm was introduced [11]. This algorithm can effectively eliminate mismatched points and improve the matching accuracy of the converted image. The experimental results show that the improved SIFT algorithm not only improves the accuracy of matching artistic decorative patterns but also significantly shortens the matching time, providing the possibility for real-time stitching. In order to fully utilize the advantages brought by modern technology, we will combine the homography matrix estimation model based on convolutional neural networks with the conformation equation of video sensors. This innovative combination not only improves the automation level of artistic image stitching but also significantly enhances the robustness and accuracy of the stitching results.

Therefore, the design and application of art decorative patterns not only face the impact and challenges of various cultures and arts around the world but also need to cater to the development of the new era and modern science and technology and absorb the national artistic characteristics and ideological connotation on the premise of paying attention to visual effects. Through the unique visual communication mode displayed by innovative design works, the diversified Art Deco patterns are combined with national cultural characteristics, and the resonance of more people is aroused. The term art deco originally referred to a pattern scheme with artistic characteristics. With the expansion

of the scope of application, the word has been given more diversified connotations. It can be oriented to practical art, but also to art architecture and other aspects. Through the pre-design of different forms, colours and structures, the decorations are given a new style. Neither Art decorative pattern nor pattern innovation exists alone, and they contain certain decorative elements. Chinese art deco patterns retain the national characteristics and cultural styles of different historical periods. The North is simple and bold with bright colours, while the South is fresh and refined with rigorous structure. With the change of times and the evolution of cultural forms, art deco patterns have also been subjected to unprecedented impact, and even face the situation of elimination and replacement. In order to fully develop the application effect of art decorative patterns, this field must be combined with modern digitalization to explore new ideas and innovative application forms of art decorative pattern design through the collaborative integration of various design links.

Traditional visual communication and pattern design only adjust information from the aspect of simple symbolic features. The multi-modal integration of art design adds different senses such as hearing, touch and smell to bring users a richer comprehensive experience. This artistic innovation of digital interaction has brought new changes to the expression of decorative patterns. Multimodality is multi-sensory integration, which is a digital development subject completed under a biological concept. By virtue of sensory organs and experience receiving information channels, the interaction and integration of modules such as sound, body language and environmental information can fully improve the communication experience between people and workers. Use the sensory nervous system to transmit new visual effects to the brain, thereby improving the freshness and sensitivity of art decorative patterns. Multimodal fusion technology can not only mobilize the sensory experience of the masses but also allow digital art to extend from a single visual communication. Through the digital expression of patterns, characters and other elements, people's aesthetic and artistic development are further influenced. This paper also explores the application effect of Art Deco pattern design with the support of multi-modal fusion technology and further analyzes the reliability of this technology in the innovation and reorganization of Art Deco patterns and the application process.

2 RELATED WORKS

In recent years, deep learning has been widely applied in fields such as image processing, image reconstruction, image recognition, and natural language processing. In order to enable machines to perceive information needs more comprehensively, it is also necessary to provide them with multimodal fusion data processing capabilities. In an integrated environment, the sounds heard, patterns seen, and sensations felt are added to modal elements to form a more diverse information database. Lee and Kim [12] analyzed the application of multimodal fusion technology. This has attracted increasing attention from researchers. The multimodal fusion model has also shown good performance in analyzing and identifying various tasks. It can provide a reliable basis for model decision-making, thereby improving the accuracy of the overall decision-making results. Different modal vectors are located in different spaces, which have inherent heterogeneity. To address this issue, multimodal data with similar semantics is computed in space to maintain the integrity of modal semantics. This optimized multimodal fusion technology has achieved outstanding results in image processing, speech recognition, and visual communication and has received widespread attention from the art and industry sectors. In addition, Lin et al. [13] also found the application of multimodal fusion technology in medical image processing. They use multimodal recombination models in medical surgery to achieve precise localization of patient lesions. By combining 3D printing technologies such as ultrasound, it is possible to analyze and process images of malignant diseases in patients, thereby improving medical outcomes. This multimodal image fusion method has played an indispensable role in the resection of various brain tumors. The Japanese anime industry is developing rapidly, and traditional anime scenes need to face various problems, such as facial recognition. Multimodal fusion technology has achieved the application of three-dimensional facial feature recognition. The abstract and structured processing, combined with the authenticity of application scenarios, improves the visual communication effect of animation works. It can be seen

that multimodal fusion technology has good performance in cross-media and cross-space areas such as high-frequency, classification, event detection, sentiment analysis, image processing, and visual recognition.

Grayscale co-occurrence matrix (GLCM), as a classic tool for texture analysis, also plays an important role in fine feature extraction of artistic decorative patterns. These descriptive words each have their own characteristics, aiming to capture the unique charm of artistic decorative patterns from different perspectives. Given that artistic decorative patterns not only have rich colours but also have complex and varied textures. Panneerselvam and Prakash [14] conducted in-depth research on the effect of combining colour information with GLCM features. To achieve better performance in image classification and retrieval of artistic decorative patterns. The experimental results indicate that in the image classification and retrieval tasks of art decorative patterns, no descriptor based on colour and GLCM co-occurrence matrix can absolutely surpass all other methods. However, some descriptors exhibit significant advantages on certain datasets or specific tasks, with their performance significantly superior to other competitors. Select five datasets with broad representativeness in the field of art decoration as experimental platforms. These datasets not only cover a variety of artistic styles and decorative elements but also ensure the universality and reliability of experimental results. This discovery not only confirms the importance of analyzing artistic decorative patterns by combining colour and texture features but also reveals the adaptability differences of different descriptors in different application scenarios. Further analysis shows that descriptors can effectively combine colour information with GLCM texture features. While considering the colour richness and texture complexity in artistic decorative patterns, better classification and retrieval results can often be obtained.

In the jacquard fabric design of artistic decorative patterns, ensuring precise editing of pattern contours and precise control of float length is key to creating exquisite works. Sun et al. [15] applied it precisely to specific parts of the pattern while cleverly avoiding unnecessary markings that could compromise the perfection of the pattern. Avoid leaving traces of binding weaving in unnecessary places to maintain a clear and harmonious boundary between the pattern and the background. Art decorative patterns are known for their complex and varied lines, colours, and textures. Therefore, in the design process, it is necessary not only to ensure that the contour lines of the pattern are smooth and flawless but also to cleverly use woven markers to control the appearance and disappearance of the float. Traditionally, the jacquard design of artistic decorative patterns relies on the designer's manual operation, and the designer needs to choose appropriate weaving marks based on the characteristics of the pattern. In order to further optimize the visual effect of the pattern, Tan et al. [16] innovatively introduced a comprehensive colour contour-oriented pattern decoration option. It is intended to control the application position and direction of weaving markers precisely. Realize flexible adjustment of floating length to achieve the perfect fusion of pattern and background boundaries. This not only greatly improves design efficiency but also ensures the purity and accuracy of pattern boundaries through a series of intelligent steps. This innovative approach not only enhances the visual effect of artistic decorative patterns but also gives designers more creative freedom and expression space.

Going back to the development of Art Deco patterns, they were rethought in the early 20th century. Many designers add art decorative elements to mechanized products, giving the product a personalized art style. From the initial combination of luxury products and artworks, it has gradually expanded to any combination of artistic elements. The use of geometric, text, and other special pattern collocation shows the characteristics of different cultures and artistic style characteristics. The essence of art decorative pattern design is to integrate simple pattern elements with decorative products, to influence the aesthetic taste of the masses from the spiritual level, and to drive the change of social consumption trends. Compared with the decorative pattern design of traditional art, in the field of art design in the modern era, the use of multi-modal integration and interaction has improved the creative space of digital art. Intelligent technology and multi-modal elements establish a new sense of experience and bring people an immersive artistic perception. The audience can be either passive viewers or active participants, which not only improves the interactivity of Art

decorative pattern applications but also enhances the appeal of digital interactive art in spatial imagination.

3 APPLICATION RESEARCH OF ART DECORATION PATTERN RECONSTRUCTION AND INNOVATIVE SCHEME DESIGN BASED ON MULTI-MODAL FUSION TECHNOLOGY

3.1 The Reconstruction Process of Art Deco Pattern by a Multi-Modal Fusion Technique

Art Deco pattern, as a visual modelling element, has experienced a long time of baptism and historical and cultural deposition, forming a decorative example with the specific symbolic significance of the country. In the development of Chinese history and art, auspicious patterns, totems, special characters and other patterns are often used as decorative patterns. In terms of cultural and national characteristics, it symbolizes wealth and good luck. We used a statistical method to extract the frequency of art deco patterns used in different artworks from the literature, as shown in Table 1:

Pattern	*Usage Frequency/%*
Geometry	80.23
Symbolic Patterns	67.8
Totem Pattern	17.9
Geometry	88.5
Symbolic Patterns	79.6
Totem Pattern	21.0
Geometry	54.2
Symbolic Patterns	63.1
Totem Pattern	74.6

Table 1: The frequency of using decorative patterns in different artworks.

As can be seen from Table 1, geometric patterns and symbolic patterns are often used in porcelain and wood carving, while totems appear in a large number of textile works of art. These stereotypical decorative art graphics have gradually integrated into people's spiritual level and become the direction of public aesthetic settings. In order to improve the modern development of Art Deco patterns, we need to rely on digital technology to constantly integrate and rebuild and give decorative patterns a new visual representation and image semantics. China has also invested more energy in the research literature on art deco patterns, ranking second in the number of related research literature. It depends on China's long history and accumulated experience in art and culture. Italy is on par with Britain in the study of the development of the arts, and the number of cases is increasing. According to the application results of art decorative pattern design in different countries, it can be seen that the rich decorative pattern system reflects the cultural essence and artistic characteristics. In the later development, the regeneration and reconstruction of the composition of decorative patterns are gradually completed by focusing on digitalization, scientific and technological materials

and innovative ideas. It not only retains the traditional artistic style but also ADAPTS to the artistic connotation of the new era. Under the condition of cultural diversity and integration in the world, people's aesthetic appreciation has gradually improved, and aesthetic attention has undergone a qualitative change. The appreciation of art deco patterns has shifted from focusing only on graphics to analyzing patterns, text, design inspiration and other aspects. In this paper, the architecture of the Art Deco pattern is reconstructed under the multi-modal fusion technology. The specific semantics of each mode are added to the decorative pattern and the image features are re-segmented. According to some pixel fusion rules, the feature information of the image and other elements is integrated. The integrated performance of the fused image can be improved from the edge contour or classification recognition. The image reorganization process under this multi-modal fusion technology is shown in Figure 1:

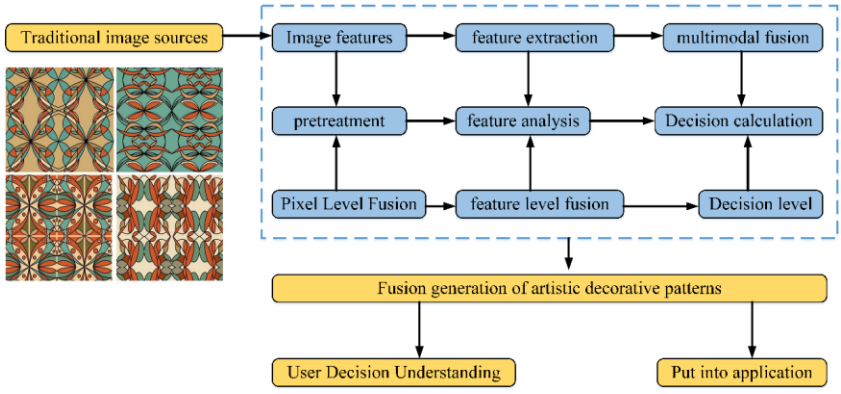

Figure 1: Image Recombination Process under Multimodal Fusion Technology.

As can be seen from Figure 1, image feature preprocessing and feature extraction are completed after the input of the traditional source image, and the output of the decision image is realized according to the mode fusion at the pixel level. The decision-making process of decorative patterns formed by multi-modal fusion is more convenient for users to understand and can also complete the conversion of three-dimensional and plane in multi-dimensional space. Traditional image segmentation and recombination are easily affected by edge blur of multi-feature points. In order to improve the quality of decorative patterns after fusion, we adopt a multi-modal fusion strategy to integrate different types of image features to improve the performance of machine learning models. The key to this fusion technology is to realize the union of different feature points and combine the converted feature semantics of each pattern together. The formula is as follows:

$$z = f(w^T v_1 + w^T v_2 + w^T v_3) \tag{1}$$

Among them, z Represents the pattern output in the shared semantic space. v An input variable representing each single mode. By means of algorithm association, different art styles are integrated into the same module. The formula is as follows:

$$z_1 = \begin{bmatrix} v \\ 1 \end{bmatrix} \times \begin{bmatrix} v_0 \\ 1 \end{bmatrix} \ldots \begin{bmatrix} v_1 \\ 1 \end{bmatrix} \tag{2}$$

The deep learning neural network algorithm is added to capture various features of the original image with the help of network parameters, such as edges, lines, angles, etc. In these low-level features, the key points of rich and fine decorative patterns are iteratively extracted, and the output image size formula is as follows:

$$out = size_1 - f(t) + 2 * p / s + 1 \tag{3}$$

Among them, out Represents size output. In deep learning and multimodal network architectures, the excitation layer is used to map the pattern output results nonlinearly. In order to reduce the influence of interference parameters due to linear dependence, the common formula of the excitation layer function is as follows:

$$f(x)=\frac{1}{1+e^{-x}} \tag{4}$$

The defects of the above functions are reflected in the phenomenon of saturation in the pattern style operation. This function affecting gradient transfer does not generate centralization. Other function formulas are used to optimize the central output results:

$$f(x)=\frac{e^{x}-e^{-x}}{e^{x}+e^{-x}} \tag{5}$$

After improving the convergence speed of the modal fusion model network, the expression is as follows:

$$f(o)=\max(0,x) \tag{6}$$

In order to reflect the difference between the predicted results of the art deco pattern and the real output image, we expressed it in terms of loss variables:

$$l(y,f(x))=(y-f(x))^{2} \tag{7}$$

In the formula, y It is real sample data. For decorative pattern processing of multiple samples, the average loss function is calculated as:

$$M(x,y)=\frac{1}{n}\sum\nolimits_{i}^{n} l(y,f(x)) \tag{8}$$

$$M(x,y)_{0}=\frac{1}{n}\sum\nolimits_{i}^{n}(y_{i}-f(x))^{2} \tag{9}$$

The loss error has a certain influence on the output derivation process of the multimodal fusion model. In order to avoid the interference of the fluctuation of such influence on the final output, we add the characteristic variable processing formula to avoid:

$$d=\frac{\partial}{\partial_{f}}=[\frac{1}{n}\sum_{i}^{m}(y-f(x))^{2}] \tag{10}$$

$$d_{\partial}=\frac{2}{n}\sum_{i}^{m}(f(x_{i})-y_{i}) \tag{11}$$

Assuming that the art deco pattern recombination process under the framework of multi-modal fusion is oriented to two - and three-dimensional data variables, we also need to redefine different neural network formulas in the calculation:

$$f(x_{1})f(x_{2})=\int_{i}^{0} f(t)f_{2}(t-x)dt \tag{12}$$

$$\int_{i}^{0} f(x-2)f_{2}(t)dt \tag{13}$$

$$f(n)*g(n)=\sum_{j}^{i} f_{i}(i,j)-f_{2}(x) \tag{14}$$

The convolution operation of different dimensions is brought into the image reorganization operation, the decorative pattern image pixels are regarded as two-dimensional arrays, and the weighted summation output is completed by combining the weight calculation formula:

$$R = \sum_{s} a_{s}^{l} * w + b_{i}^{k+s} \tag{15}$$

The Art Nouveau deco image output by multi-modal fusion technology can combine all kinds of feature information effectively, and can accurately identify the feature difference between the original image and the reconstructed image. Therefore, this kind of algorithm has certain advantages in image reconstruction. In the later stage, we will discuss in depth the innovation and application of art deco pattern design.

3.2 Innovative Design and Optimization of Multi-Modal Art Deco Patterns

Since its birth, Chinese art decorative patterns have been endowed with profound humanistic and national connotations. In the humble conditions of traditional society, people use simple geometric patterns to decorate living utensils and express their yearning for spirit and a better life. With the development of civilization and times, the types of decorative patterns in art are becoming more and more abundant. The use of text and graphics to express artistic aesthetics has become the most basic feature of decorative patterns. In modern digital life, in order to promote the inheritance and use of art deco patterns. We need to continuously explore the artistic logic and emotion behind the artistic pattern design and combine the new era technology on the basis of respecting the traditional pattern symbol to complete the innovative application of pattern design. Compared with Western art decorative patterns, they are more inclined to use natural objects as the presentation of decorative patterns, highlighting the overall rhythm of lines and patterns. The style is more liberal, diversified, and exaggerated, highlighting the artistic appeal of emphasizing the beauty of life. Chinese decorative pattern design pays more attention to the creation of charm and atmosphere in the application, which reflects the characteristics of national culture. This paper uses multi-modal fusion technology that combines image association, graphic remodeling, and other creative ideas to expand the art decorative pattern theme. Add multiple materials, texture perception, visual elements, and other different structural modules, giving art decorative patterns higher product value. Before the generation of multi-modal fusion innovative design, we used data analysis to extract the proportions of various elements in the application of Art Deco pattern design in the evolution of time, as shown in Figure 2:

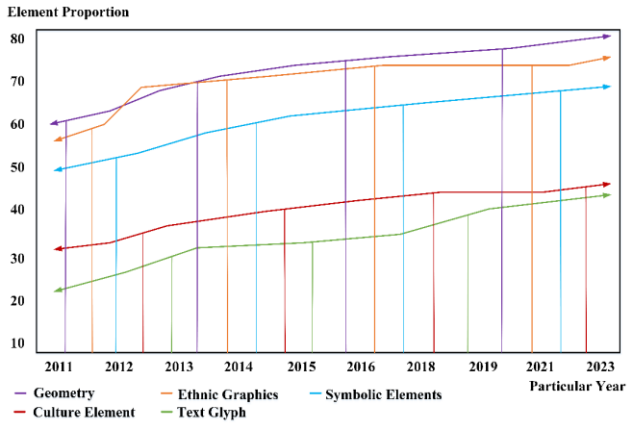

Figure 2: The proportions of various elements in the application of artistic decorative pattern design.

As can be seen from Figure 2, among the proportions of many elements, geometric figures, ethnic figures and symbolic elements account for a relatively large proportion, followed by cultural elements and text glyphs. It can be seen that there are many types of elements in Art decorative patterns. Therefore, in practical applications, we should complete the task of element segmentation of patterns and generate art decoration schemes under multi-modal fusion. The modal data suitable for 3D

object segmentation is selected to provide reliable parameters for subsequent multi-modal fusion models to generate information. The predicted image results are mapped frame-by-frame into a three-dimensional modal model to measure the actual effect of the application of art deco patterns. The innovative design requirements based on the multi-modal fusion of pattern and text are proposed. Firstly, the design sketch and art deco pattern style are preprocessed, and the application product knowledge graph is introduced to promote the development and generation of innovative design. The overall integrated Art Deco pattern innovative scheme design process is shown in Figure 3:

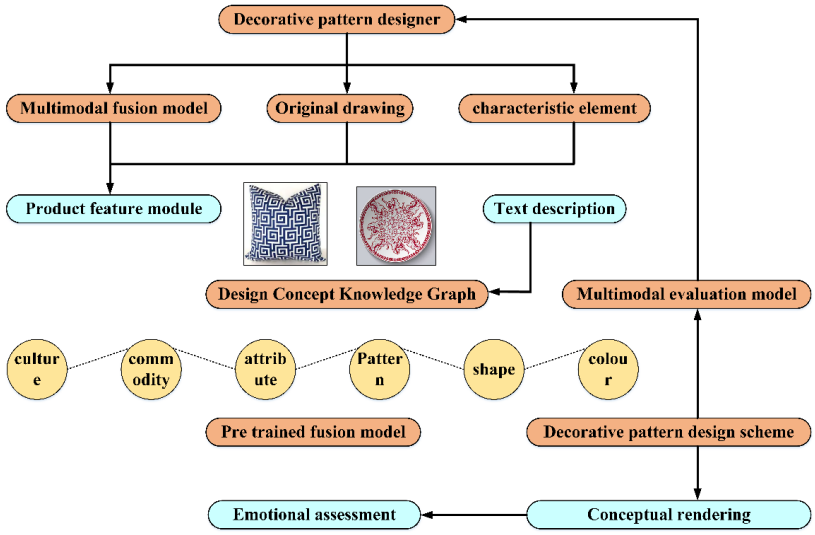

Figure 3: Innovative design process for artistic decorative patterns.

As can be seen from Figure 3, the designer generates the initial sketch based on the art deco pattern elements extracted by the multi-modal fusion technology, adds the description of relevant elements and outputs it to the product feature module. According to the design concept knowledge map, the scope of art decoration patterns in practical application is extracted. Finally, the pre-trained fusion model outputs the conceptual renderings that meet the application requirements and complete the audience's emotional evaluation and application effect analysis.

4 ANALYSIS OF RESEARCH RESULTS OF MULTIMODAL FUSION

4.1 Analysis of Decorative Pattern Research Results of Multi-Modal Fusion Technology

When the cultural diversity of the world is integrated, people's aesthetic vision continues to broaden, and the ability to pursue the beauty of decorative design products is getting higher and higher. Art Deco pattern appreciation has shifted from focusing only on the form of pattern generation to the semantics and designer inspiration contained inside the pattern. People began to think about the classic Art Deco patterns in each historical stage, and whether they were affected by history, culture, environment, economy, and society. In the early period, geometric patterns such as triangles, diamonds, and circles were used quite a lot, and later gradually evolved into birds and animals such as dragons, tigers, and birds. These pictographic patterns have strong spiritual connotations, which not only enrich the visual feelings of the masses but also reflect the current situation of cultural development at that time. In the later society, the patterns on the decorative patterns became more and more gorgeous and complex and were strongly integrated with the artistic atmosphere at that time.

In this paper, multi-modal fusion technology is used to explore the re-shaping process of artistic pattern design. It is committed to combining traditional patterns and modern inspiration to produce art decoration results in multi-dimensional space. In this chapter, we mainly verify whether the data set of the multi-modal fusion model is effective for the design recombination of decorative patterns. Firstly, 5000 real Art Deco images were extracted from the database and used for data training of the multimodal fusion model at the same resolution. The corresponding semantic labels of decorative elements are automatically generated by multi-modal fusion technology. The semantic labels automatically generated under the framework of image segmentation include geometric graphics, pictographic patterns, text patterns, and natural patterns. Using the discrete data graph, the semantic discrimination effect of Art Deco pattern elements before and after extraction by multi-modal fusion technology was compared, as shown in Figure 4.

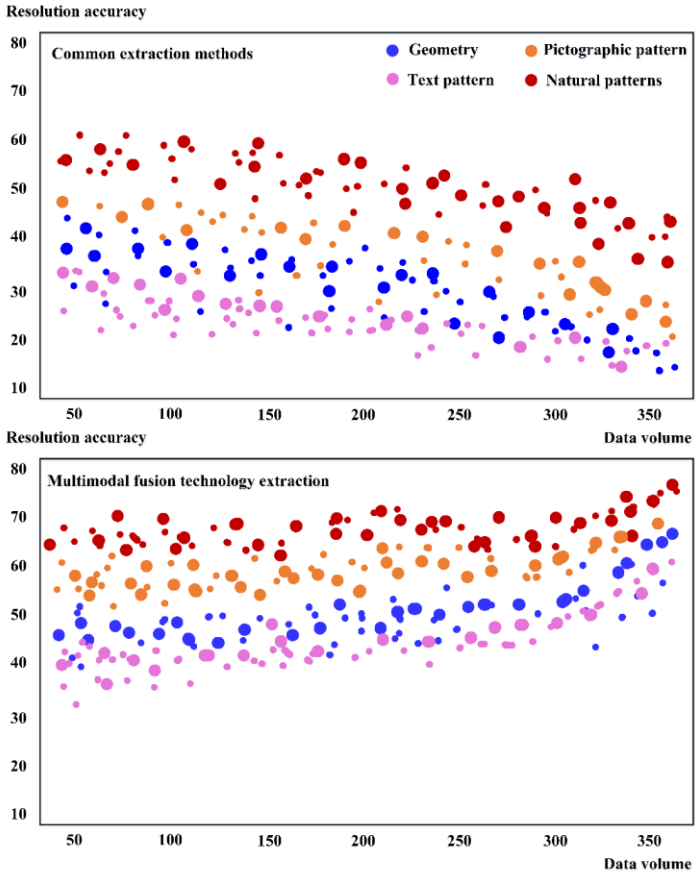

Figure 4: The semantic resolution effect of artistic decorative pattern elements before and after extraction using multimodal fusion technology.

As can be seen from Figure 4, after multi-modal fusion technology is used to extract the four semantic elements, the accuracy resolution effect is higher. This further shows that the image segmentation framework of multimodal fusion technology can be used as the basis of graphic design transformation. In addition, in terms of verifying the running time of the model, it is also found that the multi-modal fusion model has strong computing power. Compared with the traditional deep learning model and the multi-modal fusion model, the loss value changes generated by the number of iterations in the training image generation process are as follows.

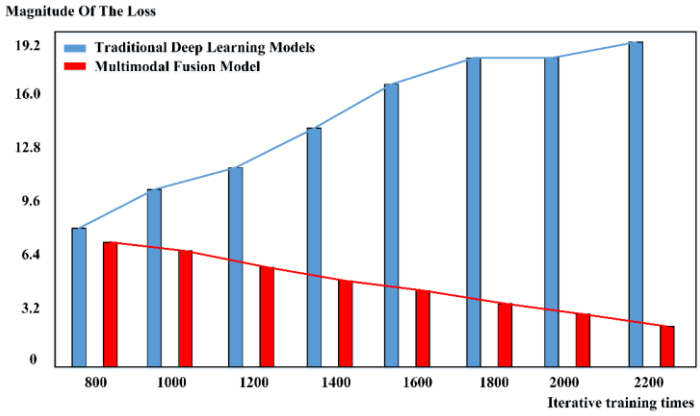

Figure 5: Comparison of changes in loss values caused by iterations.

The horizontal axis in Figure 5 represents the iterative training time, and the vertical axis represents the loss value. As can be seen from Figure 5, in the training process of the traditional deep learning model, the segmentation accuracy of the image in each iteration calculation is small, and the loss value is relatively high. In the art decorative pattern recombination of images, it is easy to appear the absence of feature elements. The iterative training model generated by multi-modal fusion technology can completely retain the element information after image semantic segmentation, and the generated innovative art decoration scheme is clearer and more beautiful.

4.2 Innovative Design and Optimization of Multi-Modal Art Deco Patterns

In terms of historical research results, Art Deco patterns summarize the development process of nations and countries. The effect of Art Deco pattern design is also closely related to the era, thinking mode and technical methods of the designer. Chinese traditional decorative patterns have formed unique and diverse distinct styles through historical evolution and development. These patterns not only play an important role in the beautification of patterns but also reflect the national implication and aesthetic taste. In the application of pattern design, we found that the scheme with a large contrast colour matching gap is easy to brings a strong impact on the aesthetic and appreciation ability of the masses. This decorative pattern style is generally based on three kinds of red, yellow, and blue with higher purity. With the addition of decorative patterns, the art pattern design style can have a strong sense of separation and a special visual balance effect. In addition, the cold and warm two-colour configuration can also give the masses psychological hints, and the special geometric modelling can also make the personalized design style more prominent in the same environment.

We use multi-modal fusion technology to optimize the application of Art Deco pattern design and integrate different patterns, text attributes, and colour matching into the Art Deco pattern design generation model. According to the analysis of audience emotion under multi-modal integration, most groups prefer the Art Deco style with digital, intelligent, and modern science and technology. Randomly selected before and after optimization using multi-modal fusion technology, the competitiveness of finished products designed with Art Deco patterns in the market changes.

As can be seen from Figure 6, art decorative pattern works generated by multi-modal fusion technology have a significant increase in competitiveness in markets with large amounts of data. This also shows that the design works generated by the multi-modal fusion technology after the segmentation of different element attributes and the recombination according to the emotional needs of the masses meet the overall needs of the masses in the current social stage.

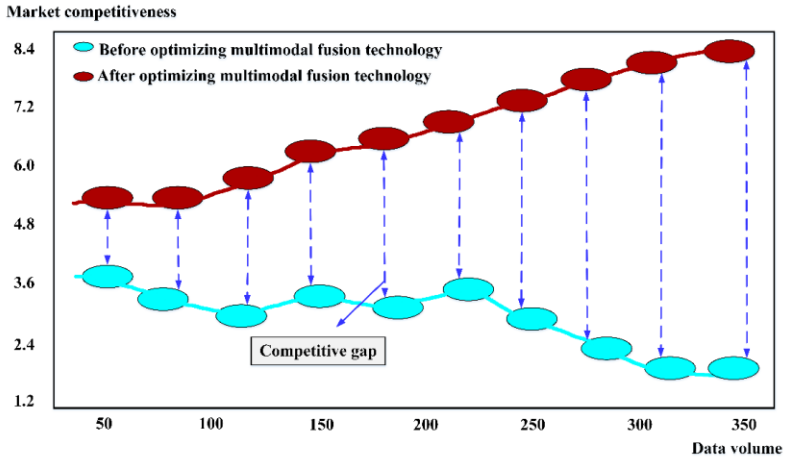

Figure 6: The competitive changes of finished products in the market for artistic decorative pattern design.

5 CONCLUSIONS

Art decorative pattern is the perfect embodiment of people's aesthetic consciousness and has very important value in the field of art design. In the digital age and with the progress and development of modern science and technology, people's living standards have improved, and their attention to the spiritual world has become more and more in-depth, which has promoted the progress of the modern art deco pattern and new aesthetic style. The introduction of digital technology not only provides scientific and technological help for decorative pattern design, but also expands the development of artistic thinking, optimizes the pattern generation process, and more and more expressive and visual works are integrated into modern applications. With the help of multi-modal fusion technology, this paper probes into the application process of art decorative pattern design. Firstly, a multi-modal fusion framework for image segmentation is proposed, which aims to recompose new decorative pattern works by using different element categories in the output image. After the fusion of traditional pattern attributes, the two-dimensional image is reconstructed in three-dimensional space and then fed into the multi-modal fusion model to generate more accurate image results. This multi-modal fusion modelling of the decorative pattern design generation process significantly reduces the redundant elements and the number of iterations interference. Finally, from the aspects of semantic and functional analysis of art decorative patterns, this paper probes into the application development of traditional art decorative patterns and the definition of abstract aesthetics. Combining with the method of image style transfer, the elements such as composition, line and colour are optimized for pattern design and give the finished application a more realistic visual effect. Using the data survey method, different groups evaluated the application effect of Art Deco pattern design before and after the application of multi-modal fusion technology. It is obvious from the analysis results that the application style of innovative decorative patterns generated by multi-modal fusion technology is more in line with people's modern aesthetic. Therefore, the research results show that the multi-modal fusion technology has a good effect on art decorative pattern element segmentation, image generation, design product optimization, and application.

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REFERENCES

[1] Asadi, A.-S.; Mohammadpoory, Z.; Nasrolahzadeh, M.: A novel content-based image retrieval system using fusing colour and texture features, Journal of AI and Data Mining, 10(4), 2022, 559-568. https://doi.org/10.22044/jadm.2022.12042.2353

[2] Cao, W.: Applying image registration algorithm combined with CNN model to video image stitching, The Journal of Supercomputing, 77(12), 2021, 13879-13896. https://doi.org/10.1007/s11227-021-03840-2

[3] Dai, Y.; Yan, Z.; Cheng, J.; Duan, X.; Wang, G.: Analysis of multimodal data fusion from an information theory perspective, Information Sciences, 623(1), 2023, 164-183. https://doi.org/10.1016/j.ins.2022.12.014

[4] Fan, M.; Li, Y.: The application of computer graphics processing in visual communication design, Journal of Intelligent & Fuzzy Systems, 39(4), 2020, 5183-5191. https://doi.org/10.3233/JIFS-189003

[5] Fan, Y.: Clothing Style Recognition and design by using feature representation and collaboration learning, International Journal of e-Collaboration (IJeC), 19(5), 2022, 1-14. https://doi.org/10.4018/IJeC.316870

[6] Gao, Z.; Li, Y.; Wan, S.: Exploring deep learning for view-based 3D model retrieval, ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 16(1), 2020, 1-21. https://doi.org/10.1145/3377876

[7] Han, D.; Cong, L.: Miao traditional patterns: the origins and design transformation, Visual Studies, 38(3-4), 2023, 425-432. https://doi.org/10.1080/1472586X.2021.1940261

[8] Hong, S.; Shen, J.; Lü, G.; Liu, X.; Mao, Y.; Sun, N.; Tang, L.: Aesthetic style transferring method based on deep neural network between Chinese landscape painting and classical private garden's virtual scenario, International Journal of Digital Earth, 16(1), 2023, 1491-1509. https://doi.org/10.1080/17538947.2023.2202422

[9] Karim, S.; Tong, G.; Li, J.; Qadir, A.; Farooq, U.; Yu, Y.: Current advances and future perspectives of image fusion: A comprehensive review, Information Fusion, 90(1), 2023, 185-217. https://doi.org/10.1016/j.inffus.2022.09.019

[10] Kovacs, B.; O'Donovan, P.; Bala, K.: Context-aware asset search for graphic design, IEEE Transactions on Visualization and Computer Graphics, 25(7), 2019, 2419-2429. https://doi.org/10.1109/TVCG.2018.2842734

[11] Khaldi, B.; Aiadi, O.; Kherfi, M.-L.: Combining colour and grey-level co-occurrence matrix features: a comparative study, IET Image Processing, 13(9), 2019, 1401-1410. https://doi.org/10.1049/iet-ipr.2018.6440

[12] Lee, Y. -J.; Kim, S.: Feature-based fashion flat sketch design using automatic module alignment algorithm, International Journal of Clothing Science and Technology, 33(5), 2021, 824-837. https://doi.org/10.1108/IJCST-10-2020-0162

[13] Lin, Q.; Man, Z.; Cao, Y.; Deng, T.; Han, C.; Cao, C.; Huang, X.: Classifying functional nuclear images with convolutional neural networks: a survey, IET Image Processing, 14(14), 2020, 3300-3313. https://doi.org/10.1049/iet-ipr.2019.1690

[14] Panneerselvam, R.-G.; Prakash, C.: Study on the float-control weaves application algorithms of computer-aided jacquard graph designing for different figured fabrics, The Journal of The Textile Institute, 114(1), 2023, 88-100. https://doi.org/10.1080/00405000.2021.2023956

[15] Sun, Y.; Weng, Y.; Luo, B.; Li, G.; Tao, B.; Jiang, D.; Chen, D.: Gesture recognition algorithm based on multi-scale feature fusion in RGB-D images, IET Image Processing, 17(4), 2023, 1280-1290. https://doi.org/10.1049/ipr2.12712

[16] Tan, Z.; Hu, Y.; Luo, D.; Hu, M.; Liu, K.: The clothing image classification algorithm based on the improved Xception model, International Journal of Computational Science and Engineering, 23(3), 2020, 214-223. https://doi.org/10.1504/IJCSE.2020.111426