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Innovation in Wickerwork Forms through the Integration of Plural Geometry and AI Algorithms, and Methods for Preserving the Cultural Symbolism of the Miao People's Flower Bamboo Hats

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Abstract As a national intangible cultural heritage, the Maonan Flower Bamboo Hat is a cultural symbol inherited by the Maonan for thousands of years. The weaving process of flower bamboo hats is exquisite and complex, and the patterns are rich in ethnic characteristics. In the process of modern social development, traditional handcraft skills face challenges such as the reduction of inheritors and low efficiency of innovative design. The development of artificial intelligence technology provides a new path for the digital protection of non-heritage, and the combination of intelligent algorithms and traditional crafts can realize the innovative inheritance of cultural symbols. Purpose: To construct the Maonan flower bamboo hat design translation model based on artificial intelligence algorithm to realize the innovation of rattan weaving art and cultural symbols inheritance. Methods: Collecting and organizing Maonan flower bamboo hat image data, using histogram equalization technology for preprocessing, proposing PSO-PCNN (Particle Swarm Optimization-Parallel Convolutional Neural Network) image style migration model, and realizing design translation through multi-feature fusion and granularity matching. The model contains five convolutional modules, uses Gram matrix to extract style features, and constructs fusion loss function to optimize image generation. RESULTS: The PSO-PCNN model reaches 0.784 in MSSIM, 19.61 in PSNR, 75.43 in FID, and 0.67 in KID, which are better than the comparison model in all indicators. User evaluation showed that 88% of the subjects thought that the translated pattern continued the traditional style (mean score of 4.18), and 80% thought that it was in line with contemporary aesthetics (mean score of 4.06). In the participatory design satisfaction survey, the satisfaction of all four cultural and creative products exceeded 70%. Conclusion: The PSO-PCNN model effectively realizes the innovative translation of the cultural symbols of the Maonan Flower Bamboo Hat, which not only retains the traditional characteristics but also meets the modern aesthetic needs, providing a feasible solution for the digital inheritance of non-heritage.

Index Terms Maonan Flower Bamboo Hat, Artificial Intelligence, Design Translation, Particle Swarm Optimization, Image Style Migration, Cultural Inheritance

I. Introduction

Rattan art as a traditional ancient and practical folk arts and crafts, in the style of self-contained system and colorful, providing to the modern design of unlimited creative source and inspiration, its natural non-carved material technology and the modern design of the pursuit of environmental protection and ecological green concept coincides with the modern design of the constant collision with the modern design of sparks [1], [2]. As a kind of non-heritage rattan weaving art, Maonan flower bamboo hat is very characteristic of ethnic culture. Flower bamboo hat is known as the Maonan “treasure”, is the symbol of Maonan culture, not only means good luck and happiness, but also a vivid embodiment of national unity and harmonious coexistence [3]. The flower bamboo hat carries the ethnic memory and wedding culture of the Maonan, and its pattern system contains nature worship and ethnic narratives, while folk songs such as “Lo Hi Song” strengthen its cultural symbolism [4]. However, there are two major pain points in the inheritance of the Maonan flower bamboo hats. First, the Maonan are located in remote and underdeveloped areas, lacking relevant regulations, measures and funding. Secondly, due to the impact of industrialized mass production, most of the technical non-heritage cultural and creative products of the production process is complex, the inheritor of the fault and aging of the main body of the inheritance of the shrinkage of the flower bamboo hat weaving skills for a long time to rely on the family, “oral teaching” [5]. Non-genetic inheritance needs to be promoted through the dual-track approach of “inherited conservation + digital empowerment” [6].

Structured design techniques work by breaking down a problem or task into manageable components for better understanding and resolution [7]. It involves organizing and arranging the elements of a system, product or project to ensure optimal performance in terms of functionality and performance. It is solved in a systematic way through structured design, enabling parametric modeling and process reconstruction to facilitate the planning of weaving heritage paths and the passing on of the weaving craft [8]. And artificial intelligence can scan the weaving art in detail, analyze and understand the pattern semantics and weaving craft skills, build a super database, realize automated and personalized production, and accelerate the speed of non-heritage product design. As well as the use of virtual reality and augmented reality and other technologies to break through the limitations of the traditional means of inheritance, so that the inheritance process of traditional crafts is more vivid and intuitive, and improve the inheritance effect [9]-[12].

As an important carrier of national culture, traditional handicrafts carry profound historical heritage and cultural connotation. As a national intangible cultural heritage, the Maonan Flower Bamboo Hat Weaving Technique, with its exquisite craftsmanship and unique cultural symbol system, shows the crystallization of wisdom of Maonan people. Flower Bamboo Hat is not only a daily necessity, but also a token of love and a symbol of good luck and happiness for Maonan youth. However, in the context of accelerated urbanization and modern industrial development, the inheritance of traditional skills is facing serious challenges. Problems such as the decrease in the number of inheritors, the long cycle of innovative design, and the low efficiency of pattern extraction constrain the development of the culture of flower bamboo hats. The rise of digital technology has opened up new ways for the protection of traditional culture. Artificial intelligence has made important breakthroughs in the fields of image recognition and style migration, providing technical support for the innovative inheritance of intangible cultural heritage. The application of deep learning algorithms to traditional craft design can realize the rapid extraction and innovative combination of cultural elements, and improve design efficiency while maintaining the continuity of cultural connotations. The Maonan flower bamboo hat weaving process is complex, including more than ten processes such as gabion selection, gabion making, weaving, etc., and the pattern pattern covers various types such as rhombus pattern, floral pattern, geometric pattern, etc. How to use intelligent algorithms to accurately extract the cultural elements of the flower bamboo hats? How to use intelligent algorithms to accurately extract the stylistic characteristics of flower bamboo hats and realize the organic integration of tradition and modernity has become a key problem to be solved.

This study adopts the method of combining artificial intelligence and structured design to construct the Maonan flower bamboo hat design translation model. Firstly, we systematically collect and organize the image data related to flower bamboo hats, and improve the image quality through pre-processing; then we propose the PSO-PCNN model, and use the particle swarm optimization algorithm to improve the convolutional neural network, to realize the multi-granularity feature extraction and fusion; we capture the style information through the Gram Matrix, and build the content loss and style loss functions, so as to generate the design scheme which retains the traditional characteristics and is innovative; finally, we test the model through experimental validation and user evaluation, to check the design of Maonan ethnicity. Finally, the validity and practicability of the model is examined through experimental validation and user evaluation. The study aims to explore the application path of artificial intelligence technology in the protection of non-heritage, and to provide theoretical basis and technical support for the digital inheritance and innovative development of Maonan flower bamboo hat cultural symbols.

II. Artistic process of rattan weaving of Maonan flower bamboo hats

With its exquisite craftsmanship, unique shape and rich symbolism, the Maonan flower bamboo hat shows a profound aesthetic connotation. It is not only a necessity in the daily life of Maonan people, but also a cultural symbol inherited for thousands of years. The production process of traditional flower bamboo hats strictly follows the craft process inherited from generation to generation, which includes the teaching of skills and incorporates rich cultural connotations. Through the skillful weaving of the craftsmen, the Maonan people incorporate their understanding of nature, life and yearning for beauty into each flower bamboo hat.

II. A. Overview of the Development of the Maonan Flower Bamboo Hat

The Maonan ethnic group's flower bamboo hat is mainly distributed in Xiannan Township in the southwestern part of Huanjiang Maonan Autonomous County, Guangxi, which is known as the "Three Nans" mountain township, namely "Upper South, Central South and Lower South". In the Maonan language, the flower bamboo hat is called "Dingka Hua", which means weaving patterns on the bottom of the hat. The predecessor of the flower bamboo hat was "Dingkajia". The slats and weaving of "Dingkajia" were relatively rough and had no patterns. The Maonan people wowed "Dingkajia" more and more delicately. They began to use ink bamboo slats to weave various patterns on the brim of the hat and named the new hat with lace "Dingkahua". The flower bamboo hat is a token of love for

young people of the Maonan ethnic group and a cultural symbol of the Maonan people. In the minds of the Maonan people, the "Dingka flower" symbolizes good fortune and happiness [13].

Flower bamboo hat to the Maonan mountain township specialties of the golden bamboo and ink bamboo for weaving materials, hats are divided into two layers, about two feet in diameter, the cap above the conical, the top of the top intertwined with 14 ~ 20 pieces less than 0.8 cm wide, about paper-thin thickness of the golden-colored bamboo pieces. Each piece of the two ends and torn scorn silk 25 ~ 30, a total of hundreds to thousands of fine as hair scorn silk scattered down for the warp, for the weft line scorn silk (such as the warp scorn silk size) is also very thin, so that can be interwoven in the diameter of two feet of the cone on the surface of the nearly one hundred smooth and dense circles. The outer edge of the cap with black fine scotch interwoven into a lace, cap the inner layer of the gold and black two kinds of fine scotch interwoven into a band about three or four inches wide, weaving a variety of floral patterns on the band. For the flower bamboo hat adds a rich connotation, the cap of the inner layer of the center on both sides and then tied on two colorful velvet band, wear on the head light and comfortable, generous and beautiful, people love.

II. B.Maonan Flower Bamboo Hat Shapes and Patterns

(1) Modeling structure. The Maonan flower bamboo hats are small and exquisite, the hats as a whole show a blunt conical shape, the top to the bottom of the shape from small to large gradually stretching, forming a gentle transition from top to bottom, giving a soft and comfortable visual experience. The top of the flower bamboo hat adopts hollow design, and the bottom of the tightly woven bamboo gabions form a sharp contrast, this combination of the real and the virtual approach, so that the flower bamboo hat has a more layered and three-dimensional sense. Flower bamboo hat is a two-layer structure, in the Maonan flower bamboo hat production concept conveys the philosophical ideas of yin and yang, harmony and coexistence, reflecting the Maonan people's respect for the equality of nature and the pursuit of the pursuit of all things, reflecting their expectations of peace and harmony, coexistence and co-prosperity of the beautiful vision [14].

(2) Patterns. The black diamond pattern is the most representative classic pattern of Maonan flower bamboo hats. After generations of inheritance of contemporary flower bamboo hat craftsmen in the inheritance of tradition at the same time continue to innovate, the Maonan brocade, Zhuang brocade and other ethnic elements into the pattern design of flower bamboo hats, so that the flower bamboo hats are increasingly rich in weaving patterns. At present, the pattern of flower and bamboo hats mainly includes text, flowers and plants, geometric patterns, with a simple and elegant flavor, elegant and delicate visual effect, reflecting the craftsmen's exquisite weaving skills and unique insights into the beauty of the infinite imagination. Analyzed from the design point of view, the weaving of flower and bamboo hats applies the laws of beauty of form, such as contrast, symmetry, continuity, repetition and equilibrium, so that the flower and bamboo hats present a rich and harmonious visual aesthetic on the small hat surface.

II. C.Craft Process of Maonan Flower Bamboo Hat

The weaving process of Maonan Flower Bamboo Hat is very delicate and complicated, reflecting the superior handcraft skills and unique aesthetic taste of the Maonan people. The Maonan Flower Bamboo Hat has been inheriting the ancient complicated steps, and the whole process includes the steps of “selecting gimlets → making gimlets → molding → knotting → knitting → shaping → integrating → strangling → protecting the top → oiling → finished products” and so on. The details are as follows:

The selection of gabion, or material, takes place after the summer solstice and before the first day of fall, when straight, well-balanced, two-year-old golden bamboo and ink bamboo are selected to ensure that the bamboo is not too wet or too brittle. Gabion making includes the process of breaking the bamboo and cutting the strips, breaking the gabions and combing the threads to obtain hair-thin gabions, which are used in the next step of the weaving process. Moulding, which involves attaching the tip of a pre-woven five-pointed star hat to the mould to complete the top part of the hat. Knotting, through the process of pressing, tightening, pulling, hammering, sprinkling and so on, makes the gabions tighten the gaps between each other until the top of the hat takes on a conical shape. Weaving, that is, the process of knitting the hat body, including the surface knitting, lining knitting, closing, hat band knitting and other parts. The shaping process starts from the beginning of weaving and continues until the final product is completed. Integration, that is, the knitting of the surface layer, the inner layer together, with needle and thread sewing cap edge. Le edge, is then further fixed along the edge gap between the surface and inner layers to form the edge. Protect the top, is to use the goose feather tube to break the top tip, so as to avoid wear and tear in the subsequent use, reducing the service life of the flower bamboo hat, nowadays the flower bamboo hat more as a decorative object, the protection of the top of the step has been omitted in the actual production. Painting oil, refers to the use of tung oil refining paste painted on the surface of bamboo hats, play a role in anti-corrosion and

anti-moth, and now this step is also combined with the actual production has been improved. Finished product, after the completion of the above procedures, flower bamboo hat has been basically completed.

If the flower bamboo hat is not used for production labor, it is necessary to add some tassels, laminations, pom-poms and other decorations according to the scene of its use.

III. Maonan Flower Bamboo Hat Design Translation Model Construction

As an important part of regional cultural genes, intangible cultural heritage plays an indispensable role in the development of excellent traditional culture. With the rapid development of intelligent technology, the combination of intangible cultural heritage and artificial intelligence digitization has received widespread attention. Intelligent technology provides a new way of thinking for the protection and inheritance of intangible cultural heritage, and at the same time, it also brings more application potential for intangible cultural heritage. The deep fusion of intelligent technology and Maonan flower bamboo hats is used to realize the innovative inheritance of Maonan flower bamboo hat cultural symbols by giving them an innovative form through algorithmic models.

III. A. Flowering bamboo cap data collection and pre-processing

III. A. 1) Flowering bamboo cap data collection

The design translation of Maonan Flower Bamboo Hat should have cultural attributes and creative attributes, the innovative design of Maonan Flower Bamboo Hat is mostly based on physical carriers, and the style of Maonan Flower Bamboo Hat is integrated into the style of Maonan Flower Bamboo Hat through daily necessities, packaging products, clothing accessories, etc., so as to create Maonan Flower Bamboo Hat cultural IP, so that the graphic design of the style of Maonan Flower Bamboo Hat has become a key point of the design translation. Based on this, it is necessary to fully collect the relevant data of Maonan flower and bamboo hats to provide data support for the translation of Maonan flower and bamboo hat design with the support of intelligent algorithms.

According to the main techniques of Maonan Flower Bamboo Hat classification collection and screening, and relying on the techniques presented graphic features, color features, behavioral meanings for vocabulary summarization. By collecting a large number of Maonan flower bamboo hats related picture data, various techniques are cropped and categorized. After extracting the characteristic pictures, a large number of pictures that can represent the style characteristics of Maonan Flower Bamboo Hat are selected from the texture characteristics, behavioral meanings and color characteristics based on the data collection and tertiary analysis. For artificial intelligence algorithms, the larger the number, the higher the accuracy of analysis and categorization. Through expert interviews, questionnaires and on-site surveys, 10% to 15% of representative pictures related to the Maonan flower bamboo hat technique are further selected. According to the previous categorization of commonly used techniques in Maonan flower bamboo hats, the adjectives obtained through questionnaire surveys of cultural research experts, folk artists, and arts and crafts masters will be classified. From the questionnaires of these three groups of people, the graphic symbols and vocabulary that best represent the techniques of the Maonan flower bamboo hats will be selected to provide a data base for style migration and design translation of the AI algorithm in the future.

III. A. 2) Flowering bamboo hat data preprocessing

After obtaining the original data of Maonan flower bamboo hats, this paper uses histogram equalization to preprocess the original image as a way to ensure the Maonan flower bamboo hat image effect.

Histogram Equalization (HE) uses the gray scale mapping method to convert the original image gray scale histogram from a more concentrated gray scale interval to a relatively uniform distribution of the output image gray scale level, thus improving the image effect.

In the histogram equalization algorithm X denotes the input original image, $Y = f_{HE}(X)$ denotes the histogram equalization algorithm, Y denotes the image after enhancement by the algorithm, $X_1, X_2, \cdots, X_n$ denotes the n sub-images composed by extracting part of pixel points in the original image according to a given attribute, and the number of times of the specific equalization in the model determined by the n value. Knowing that the total gray level is L and the cumulative probability distribution exhibited by $c(X_k)$ denotes the input image gray level, the transformation relationship between the original image and the output image after histogram equalization is:

$$Y = f_{HE}(X_n) = X_1 - (X_{L-1} - X_1)c(X_n) \tag{1}$$

Data enhancement is an important technique used in deep learning image processing to improve the quality and quantity of training image data. The technique involves applying various transformations and modifications to the input image data to produce a new image that is similar to the original image but with variations that help improve the accuracy and robustness of the model.

A common method used in image processing to expand the dataset and improve the efficiency of model training is the data augmentation operation, when there is insufficient data, the commonly used augmentation methods against image data are random cropping, random rotation, random scaling, color transformation, etc., which can be used to achieve the effect of expanding a small amount of the data while keeping the patterns in the data unaltered as much as possible. Although the training effect will be better if more data expansion methods are adopted, considering the cost of data batch processing time during training and controlling experimental variables, this paper adopts the methods of random rotation and random clipping to carry out preliminary data enhancement. The expressions for random rotation and clipping are denoted as respectively:

$$I(x,y) = I\left(x \cdot \cos\theta - y \cdot \sin\theta, y \cdot \cos\theta + x \cdot \sin\theta\right) \tag{2}$$

$$I(x,y) = I\left(clip(x,\xi), clip(y,\xi)\right) \tag{3}$$

where I represents a two-dimensional image matrix, $I(x,y)$ represents a pixel point on the matrix, θ represents the angle of rotation along the coordinate system, the $clip()$ function represents the truncation function, ξ is a given random number, and $clip(x,\xi)$ and $clip(y,\xi)$ represent taking $x-\xi, y-\xi$, i.e., taking the sub-matrix of the original image matrix as index. Random rotation, random clipping and other image data enhancement methods, which are equivalent to scaling or linear transformation of patterns in two-dimensional space, can play a role in data generalization for the training of neural networks.

III. B. Flower Bamboo Hat Design Translation Modeling

III. B. 1) Designing a Translation Modeling Framework

The traditional convolutional neural network model can only extract single granularity feature information, while ignoring other granularity feature information on other different feature levels of the image, which leads to limited migration effect. Aiming at this problem, this paper proposes to design a style migration design translation model for Maonan flower bamboo hats based on a combination of multi-feature fusion and granularity matching scheme [15]. The architecture of the PSO-PCNN model is shown in Fig. 1, which can extract various granularity of feature information of the input images of the style and content of the Maonan flower bamboo hats and complete the matching based on the feature information of the corresponding granularity, and then carry out the multi-granularity feature fusion, so as to improve the conversion quality.

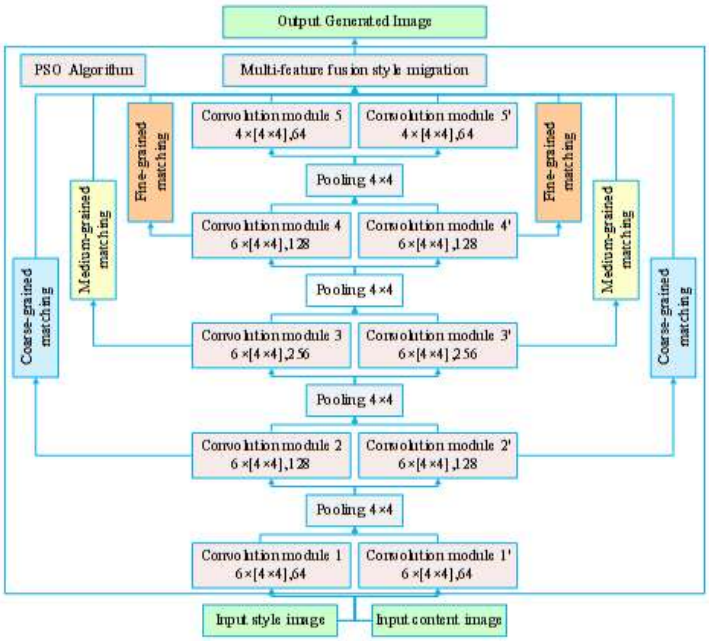


Figure 1: PSO-PCNN image style transfer algorithm

PSO-PCNN model is an image style migration model consisting of particle swarm optimization algorithm and parallel convolutional neural network.Parallel Convolutional Neural Network (PCNN) has a total of five convolutional modules with multiple convolutional and pooling layers and normalization and activation function layers.Each of the

first four modules has eight convolutional layers, with 32, 64, 128, 256, 512, 256, 128, 64 channels, and the fifth module has two convolutional layers with 32 channels. Each convolutional module has a convolutional kernel size of 4 × 4 and a pooling layer size of 4 × 4. Also the model includes convolutional layers for the judgment of whether the input matches the output or not and for feature fusion.

A particle swarm optimization algorithm was used to adjust the network weight thresholds during the backward propagation portion of the network training phase. Specifically, the error between the model output and the target output is designed as a fitness function, and the particle swarm optimizes the fitness function to adjust the network weight threshold to seek the global optimal solution. The PSO algorithm is incorporated into the training phase of the neural network, i.e., the core weights network in the network model that needs to be trained corresponds to the particles in the PSO algorithm. Firstly, the position of the particles in the particle swarm is calculated, after which the initial value is restored, and it is judged whether the solution of all the particle values can reach the constraint range, and if it does, then it ends, and vice versa, the speed, position and other information of each particle is calculated iteratively until the optimal solution of the whole group is obtained. Define the update rules for the training phase of PSO-PCNN image style migration model as follows:

$$v_i = w^{(t)} v_i + c_1 \cdot rand(\,) \cdot (p_{best,i} - x_i) + c_2 \cdot rand(\,) \cdot (g_{best,i} - x_i) \tag{4}$$

$$x_i = x_i + v_i \tag{5}$$

where i denotes the total number of particles in the convolutional network, v_i denotes the movement speed of the particles, $rand(\,)$ is a randomly generated number in the range $(0,1)$, x_i denotes the current position of the input image pixel, $p_{best,i}$ is the current particle optimal solution, $g_{best,i}$ is the global particle optimal solution, c_1 and c_2 are the learning factors, the inertia factor $w^{(t)}$ will exist linearly decreasing, and:

$$w^{(t)} = (w_{ini} - w_{end})(G_k - g) / G_k + w_{end} \tag{6}$$

where G_k is the maximum value of the computed update count, g is the current update count, and w_{ini} and w_{end} are the maximum values of the computed update for the first inertia parameter and the inertia parameter, respectively.

III. B. 2) Image Content Acquisition Reconstruction

Typically, each layer in the network defines nonlinear filter banks whose complexity increases with the position of the layer in the network. Thus, in each layer of a convolutional neural network, the input image is encoded. With N_l filters, there are N_l features, assuming that the size of the features is M_l, and that the feature vectors of each layer are stored in the matrix p^l. Then F_{ij}^l represents the feature representation of the i th filter of the l th layer at position j.

To visualize the image information encoded at different layers of the hierarchy, gradient descent can be performed on a white noise image to find another image that matches the feature response of the original image. Let $\vec{p}$ and $\vec{x}$ be the original and generated images, and P_{ij}^l and F_{ij}^l be the corresponding feature representations in their layers. Define the squared error loss between two feature representations with the following formula:

$$\mathrm{L}_{content}(\hat{p}, \hat{x}, l) = \frac{1}{2} \sum_{i,j} (F_{ij}^l - P_{ij}^l)^2 \tag{7}$$

The derivative of this loss is shown in the following equation:

$$\frac{\partial \mathrm{L}_{content}}{\partial F_{ij}^l} = \begin{cases} \left(F^l - P^l\right)_{ij} & if\ F_{ij}^l > 0 \\ 0 & if\ F_{ij}^l < 0 \end{cases} \tag{8}$$

When convolutional neural networks are trained in object recognition, they form representations of the image that become more and more visible as the processing level increases. Thus, along the hierarchy of the network, there is increasing sensitivity to the high-level content of the image, but relatively unchanged with respect to its precise appearance. Thus, higher levels in the network typically capture the high-level content in terms of the arrangement in the input image, but do not constrain the exact pixel values very tightly. Conversely, those from lower layers can simply reproduce the exact pixel values of the original image.

III. B. 3) Image Style Feature Acquisition

Existing related studies, after reconstructing the abstract features in the middle layer of the VGG network, observe that the neural network is able to extract the image content feature information from any image, and the style feature information can be extracted from any image by constructing the Gram matrix. Accordingly, in this paper, the Gram matrix is first used to extract the style information in the Maonan Flower Bamboo Hat specified style image, and then, according to the image reconstruction method, the pixel values of the reconstructed image are updated by the gradient descent method, so that the Gram matrix of the content map approximates the Gram matrix of the style map. Then it makes the high-level feature information of the neural network close to the feature information of the content map, and finally obtains the stylized result map of Maonan flower bamboo hats.

$$L_{total}(I_c, I_s, I) = \alpha L_c(I, I_c) + \beta L_s(I, I_s) \tag{9}$$

where α is the balanced weight coefficient of the image content loss function $L_c(I, I_c)$, and β is the image style loss function $L_s(I, I_s)$ of the balanced weight coefficients. And the image content loss L_c is defined by the squared Euclidean distance between the content image's content feature representation F^l in the l th layer of the VGG, and the stylized image I 's feature representation F^l initialized with the noisy image as:

$$L_c = \sum_{l \in \{l_c\}} \left\| F^l(I_c) - F^l(I) \right\|^2 \tag{10}$$

where $\{l_c\}$ denotes the set of VGG model layers used to compute the content loss. For the style loss L_s, the style loss is defined by the squared Euclidean distance between I_s and the I Gram matrix-based representation as:

$$\sum_{l \in \{l_c\}} \left\| G\left(F^l(I_s)'\right) - G\left(F^l(I)'\right) \right\|^2 \tag{11}$$

where G denotes the Gram matrix of the content image and the style image, and $\{l_c\}$ denotes the set of VGG model layers used to compute the style loss.

III. B. 4) Fusion Loss Function Construction

In order to generate style migration images with better effect, this paper defines two functions, content loss function and style loss function respectively. On the basis of content reconstruction and feature representation of Maonan flower bamboo hat image, the image style function based on Gram matrix definition is obtained to be represented as:

$$G_{i,j}^l = \sum_k C_i^l C_j^l \tag{12}$$

where C_i^l and C_j^l denote the activation values of the i th and j th filters, respectively, when the image passes through the l th convolutional layer, and the inner product of the two is the correlation between the features extracted by different filters.

The style loss function of the l th layer and the model as a whole are denoted as:

$$E_i = \sum \left(G^L - A^L \right)^2 \tag{13}$$

$$L_{style} = \sum_{l=0}^{L} w_l E_i \tag{14}$$

where G^l is the Gram matrix of the generated image, A^l is the Gram matrix of $\vec{a}$, and w_l is the weight of each layer of style loss, which is multiplied by the value of the style loss of each layer and then summed up to get the overall style loss of the model.

$$L_{total}(\vec{p}, \vec{a}, \vec{x}) = \alpha L_{content} + \beta L_{style} \tag{15}$$

The above equation represents the total style migration loss, which contains two parts, content loss and style loss, where α and β are the weights of content loss and style loss in the image style migration algorithm, respectively.

IV. Maonan flower bamboo hat design transfer model validation

Maonan Flower Bamboo Hat is the crystallization of the culture and wisdom of the ethnic minorities, and its cultural symbols carry the historical memories and legends of the nation. With the development of the times and the

advancement of science and technology, the modern industrial products of simple design and low cost have formed a great influence and impact on the traditional culture of the ethnic minorities, and the number of cultural inheritors has gradually decreased in the process of urbanization and the development of the modern society, so that the protection and innovation of the related culture have become more and more important. Therefore, the protection and innovation of related culture become more and more important. However, the innovation of traditional ethnic cultural symbols requires a long practical process, and there are problems such as low efficiency of manual extraction of patterns, difficulties in automated extraction, and insufficient inspiration for innovation. How to realize the rapid innovation of Maonan Hua Zhu Hat cultural symbols is an important problem in the process of protecting and developing Maonan Hua Zhu Hat cultural symbols.

IV. A. Validity of the PSO-PCNN model

IV. A. 1) Comparison of Stylized Flowering Bamboo Hats

In order to effectively analyze the feasibility of the PSO-PCNN model established in this paper in designing the translation of the Maonan Flower Bamboo Hat cultural symbols when they are stylistically migrated, this paper measures its designing and translating effect through objective evaluation indexes. While a single objective evaluation index cannot comprehensively measure the quality of the image, therefore, the study in this paper mainly chooses four indexes, namely, MSSIM, Peak Signal-to-Noise Ratio (PSNR), Average Gradient (AVG) and Degree of Representation of Significant Information (QAB/F), as the evaluation criteria to quantitatively evaluate the performance of the different design-translation models.

MSSIM represents the average of the structural similarity (SSIM) values of the content image and the migrated image and the SSIM values of the style image and the migrated image, SSIM is used to characterize the structural similarity of the two images, and the value ranges from 0 to 1. The closer the value is to 1, it means that the migrated image is more similar to the two images.PSNR, which is determined by the peak value of the image signal and the mean squared error, reflects the distortion degree of the image, and the higher the PSNR value is, the more similar is the PSNR value. The larger the value of PSNR, the better the effect of the stylized image.AVG quantifies the gradient information of the migrated image and can characterize its details and texture features, the larger the value of AVG, the more details and textures are included in the migrated image.QAB/F uses the local metric to estimate the degree of performance of the significant information from the inputs in the stylized image, the higher the value of QAB/F, the better the quality of the stylized image, and the closer the value to 1 represents the edge information, the higher the value to 1 represents the edge information, and the closer the value to 1 represents the edge information. The closer the value is to 1, the better the retention of edge information is.

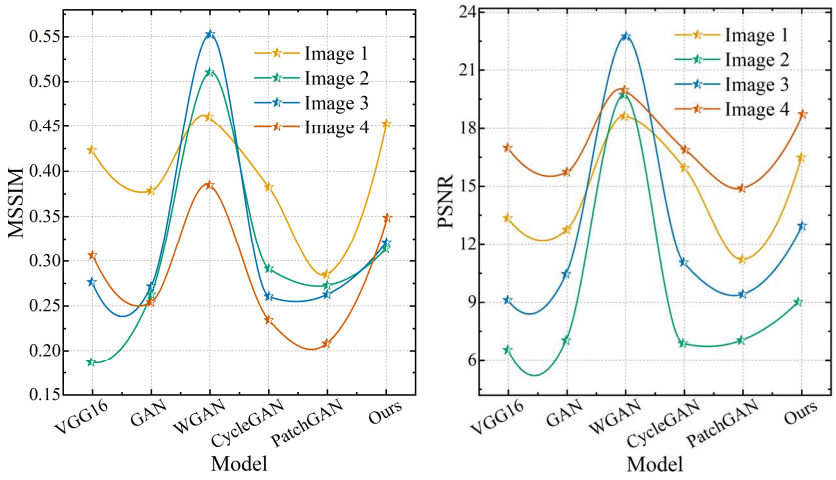
Based on the Maonan Flower Bamboo Hat dataset established in this paper, it is divided into training set and testing set according to the ratio of 7:3. After the training is completed, four Maonan flower bamboo hat images are randomly selected, and GAN, CycleGAN, VGG16, PatchGAN, and WGAN are chosen as comparisons, and the objective evaluation results of different models are obtained as shown in Figure 2. Among them, Fig. 2(a)~(d) shows the evaluation results of MSSIM, PSNR, AVG and QAB/F, respectively.

As can be seen from the figure, the average structural similarity and peak signal-to-noise ratio of the WGAN model are significantly higher than the other methods, and it also has the smallest average gradient and QAB/F, which indicates that this method maximally preserves the semantic content of the content image with the smallest degree of image distortion, and also reflects the fact that the content image is not combined with the texture and color of the stylized image, and does not really achieve the style migration. Comparing this paper's method with the other four methods, it has a better performance in terms of average structural similarity, peak signal-to-noise ratio, average gradient and QAB/F, which indicates that this paper's method presents a better effect in terms of retaining the semantic content of the Maonan Flower Bamboo Hat cultural symbols and combining with the stylized texture, maximally realizing the stylization of the image, which can provide a new direction for the innovative translation and It can provide a new direction for the innovative translation and inheritance development of Maonan flower bamboo hat cultural symbols.

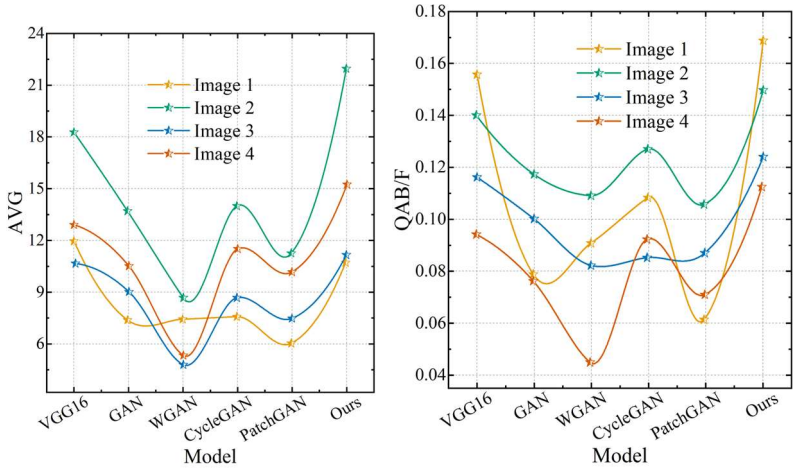
IV. A. 2) Analysis of ablation experiment results

In the training process of PSO-PCNN model, this paper trains three models, WAGN, CycleGAN and PSO-PCNN, on the self-constructed Maonan Flowering Bamboo Hat dataset, and selects the evaluation score as the evaluation index, which is used to measure the quality effect of the model in performing the Maonan Flowering Bamboo Hat style translation image with diversity. Under the same number of iterations, the higher value of the evaluation score indicates that the image quality of the style translation migration is better and the convergence speed is faster. Figure 3 shows the results of convergence speed comparison of different models. From the figure, it can be seen that among the three comparative models, the PSO-PCNN model proposed in this paper can converge faster and obtain higher evaluation scores, and its image quality is better when it is used for the Maonan Flower Bamboo Hat style image translation. The image quality after designing and translating can provide new ideas for the innovative

design of Maonan Hua Zhu Hat cultural symbols, and also promote the innovative inheritance and development of Maonan Hua Zhu Hat cultural symbols.



(a) MSSIM (b) PSNR



(c) AVG (d) QAB/F

Figure 2: Objective evaluation

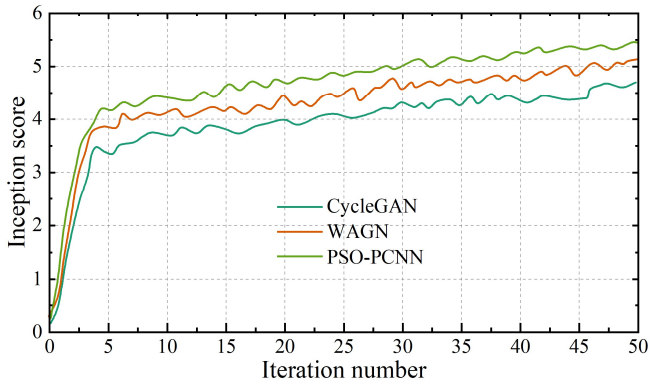


Figure 3: Comparison results of convergence speed

This experiment is to make two changes under the network structure of CNN, firstly, a five-layer parallel convolution kernel is added to the original CNN as a way to enhance the extraction capability of the style features

of the Maonan flower bamboo hats, and thus to improve the quality of the image conversion. Secondly, the PSO algorithm is used to adjust the network weight threshold in the backward propagation part of the network training stage, so as to obtain the global optimal solution, which further promotes the quality of the style-converted images. In order to verify the effectiveness of the network structure modification, this experiment conducted four sets of ablation experiments based on the improved network structure on the Maonan Flower Bamboo Hat dataset. The first set of ablation experiments is without any modification to the traditional CNN, the second set of experiments is with the addition of a five-layer parallel convolutional kernel to the original CNN, and the third set of experiments is with the PSO algorithm to adjust the network weight threshold in the original CNN. The fourth set of ablation experiments uses the improved PSO-PCNN model. On the basis of the previous PSNR and MSSIM evaluation indexes, this paper further chooses FID and KID as evaluation indexes, so as to verify whether each module of the network is effective. Table 1 shows the results of the ablation experiment.

According to the values of the two indexes PSNR and MSSIM in the table, it can be seen that the experimental results of the five-layer parallel convolutional kernel added to the original CNN network are better than the traditional network structure. This indicates that the use of five-layer parallel convolutional kernel can improve the performance of the network to some extent. After using the PSO algorithm to optimize the network weights, the CNN is better than the original network structure model with only five layers of parallel convolutional kernels, which indicates that the addition of the PSO algorithm better preserves the color information and texture, structure and other features of the original image domain, and plays a certain optimization role in the network model. And relatively speaking, after adding the five-layer convolutional kernel and PSO algorithm, the overall FID and KID of the model show a decreasing trend, which indicates that the cultural symbols of the Maonan flower bamboo hats after designing and translating are more similar to the original images, and the closer the data distributions of the real image and the generated image are. In summary, the PSO-PCNN model proposed in this paper has better translation performance and better translation effect when designing and translating the Maonan Flower Bamboo Hat cultural symbols, which can provide a new direction for the innovative design of Maonan Flower Bamboo Hat cultural symbols.

Table 1: Ablation experiment results

Model	PSNR	MSSIM	FID	KID
CNN	14.72	0.731	82.15	1.94
PCNN	16.53	0.735	76.34	1.53
PSO-CNN	18.96	0.769	80.28	0.85
PSO-PCNN	19.61	0.784	75.43	0.67

IV. B. Effectiveness of Cultural Translation of Maonan Flower Bamboo Hat

IV. B. 1) Evaluation of cultural translation results

From the perspective of innovation and inheritance of cultural symbols of Maonan Flower Bamboo Hat, this paper utilizes PSO-PCNN model to translate its style migration design. Then, based on the constraints of the traditional layout and weaving rules of Maonan flower bamboo hats, filling and color matching and other conditions, the generated graphic units are used to adjust and combine into a brand-new pattern of Maonan flower bamboo hats again and weave them into brand-new Maonan flower bamboo hats cultural and creative products. In order to verify whether the graphic scheme derived from the PSO-PCNN model is innovative while continuing the traditional Maonan flower and bamboo hat rattan weaving art style and meets the aesthetic needs of contemporary people, a psychological perception evaluation test was conducted on 50 subjects by distributing a questionnaire. The questionnaire was based on the semantic difference method and consisted of two sets of adjective pairs on a five-point Likert scale (1~5 points). The group of subjects included college students, college teachers, designers and so on. The subjects were first asked to browse a certain number of pictures of the Maonan Flower Bamboo Hat to make a visual impression of the stylistic features of the Maonan Flower Bamboo Hat, and then scored on the evaluation scale of the Maonan Flower Bamboo Hat Design Translation Program. The scoring data of the recovered questionnaires were statistically analyzed to obtain the evaluation results of the testers. Table 2 shows the evaluation results of the Maonan Flower Bamboo Hat cultural symbol design translation.

The results show that a total of 44 people thought that the Maonan Flower Bamboo Hat pattern after the translation of the design completely continued or basically continued the style of the Maonan Flower Bamboo Hat (the average score was 4.18), and 80% of the test subjects thought that the pattern completely conformed to or basically conformed to the contemporary aesthetics (the average score was 4.06). The mean score of both results was greater than 4. The evaluation data indicates that this paper uses the PSO-PCNN model as the basis for designing and translating the cultural symbols of the Maonan Flower Bamboo Hat not only continues the traditional Maonan Flower Bamboo Hat rattan weaving art style, but also caters to the aesthetic orientation of contemporary people. It

can be seen that when the PSO-PCNN model is used to deduce the cultural symbols of Maonan flower bamboo hats, it should be combined with the classic patterns, compositional skeleton, and weaving techniques of Maonan flower bamboo hats to fill the organizational picture, so as to continue the overall style of Maonan flower bamboo hats culture. At the same time, by simplifying the extracted shapes, optimizing the pattern layout, and adjusting the rattan weaving process, the cultural symbols of the Maonan flower and bamboo hats generated from the PSO-PCNN model can be more in line with the contemporary aesthetic needs.

Table 2: Evaluation of cultural translation results

Problem	Attitude	Number	Score	Means
Whether or not the traditional style of Huazhu hat	Not at all	0	0	4.18
	Not very capable	2	4	
	General	4	12	
	Basic continuation	27	108	
	Complete continuation	17	85	
Whether it meets the contemporary aesthetic demands	Completely inconsistent	0	0	4.06
	Not quite consistent	3	6	
	General	7	21	
	Basically consistent	24	96	
	Completely consistent	16	80	

IV. B. 2) Satisfaction with rattan design

Under the development trend of the age of digital intelligence, users are no longer satisfied with products or services that are owned by a single commodity. On the basis of satisfying their basic material needs, they begin to seek to create their own lifestyles and seek to meet their own needs. Participatory design is a modern user-centered design method that integrates users into the design process and collaborates with each other under the premise of respecting their backgrounds, abilities and ideas. Compared with traditional design methods, user participatory design methods are more flexible and open, allowing users to maximize their participation in the design process, so that they can get the best interactive experience.

In this paper, based on the cultural symbols of the Maonan Flower Bamboo Hat extracted from the PSO-PCNN model, the elements of the Maonan Flower Bamboo Hat are integrated into the cultural and creative products such as rattan skeleton screen, VR rattan pattern experience, rattan hamper, and the Maonan Flower Bamboo Hat, which are represented by the letters MN1, MN2, MN3, and MN4, respectively, and 120 subjects in different fields are selected to participate in the rattan weaving skills of the Maonan Flower Bamboo Hat in the innovation design. In order to verify the subjects' satisfaction in the dissemination of cultural symbols of Maonan Flower Bamboo Hat supported by participatory design, this paper designed a questionnaire to explore the subjects' satisfaction with the participatory design model, which was based on a five-point Likert scale (very dissatisfied~very satisfied, i.e., TK1~TK5). A total of 120 questionnaires were distributed in this survey, and the preliminary survey learned that there were 115 valid questionnaires. Because some of the questionnaires of the survey population did not fill in the preference, age, etc., 100 valid questionnaires were finally determined as the sample set of statistical data. Figure 4 shows the satisfaction survey of Maonan flower bamboo hat rattan weaving art innovation under participatory design.

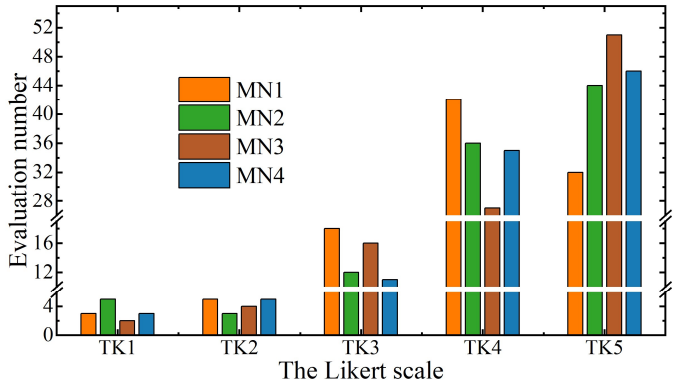


Figure 4: Satisfaction survey situation

As can be seen from the table, overall, the subjects' satisfaction with the Maonan ethnic flower bamboo hat rattan weaving art innovation design mode under the participatory design mode is relatively high, and the number of people who expressed satisfaction and great satisfaction in each of the four types of cultural and creative product design reached more than 70, and the overall satisfaction can reach more than 70%. Therefore, on the basis of using artificial intelligence algorithm to obtain the cultural symbols of Maonan Flower Bamboo Hat, combined with participatory design to give the Maonan Flower Bamboo Hat cultural symbols and the innovative development of cultural and creative products. On the basis of satisfying the audience's sense of participation and experience, it realizes the development of the rattan weaving art of Maonan ethnic flower bamboo hats, and also provides support for the development of the cultural symbols of Maonan ethnic flower bamboo hats.

V. Conclusion

In this paper, the PSO-PCNN-based Maonan flower bamboo hat design translation model is successfully constructed, realizing the deep integration of traditional rattan weaving art and artificial intelligence technology. The experimental results show that the PSO-PCNN model performs well in image quality evaluation, with a peak signal-to-noise ratio of 19.61 and a structural similarity index of 0.784, which is significantly better than the traditional method. The ablation experiment verifies the effectiveness of the parallel convolutional structure and particle swarm optimization algorithm, with fast model convergence and high quality of the generated images. The evaluation of the effect of cultural translation showed that 44 subjects thought that the design scheme continued the traditional style, with a mean rating of 4.18 points; in the participatory design survey, the user satisfaction of the four types of cultural and creative products exceeded 70%. This study provides an innovative path for the digital protection of Maonan flower bamboo hats, effectively solves the efficiency and innovation problems faced by traditional handcrafts in modern inheritance, and is of great reference significance for the protection and development of other intangible cultural heritage.

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