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# Research on the Innovation of Rattan Weaving Art Design Form and Inheritance of Cultural Symbols of Maonan Flower Bamboo Hat Based on Complex Geometry and AI Algorithm

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ABSTRACT
The field of artificial intelligence provides a new practical path for the inheritance and protection of non-heritage art. This paper proposes an innovative morphological design method for rattan weaving art based on fractal theory, and the grasshopper plug-in is selected to establish a parametric design model. The fractal graphics generated by the iterative function system are used as the input graphics, and the GrabCut algorithm and VGG16 neural network are combined to propose a graphic rendering method based on style migration containing elements of the cultural symbols of the Maonan Flower Bamboo Hat, and to realize the inheritance of the cultural symbols of the Maonan Flower Bamboo Hat. In the high preference survey, the A1 and A4 features of the sun hat in the questionnaire results are consistent with the preference results derived from the fractal design, and the questionnaire results of the handbag and handkerchief are also consistent with the preference results derived from the fractal design. It shows that the product form design method of Maonan flower bamboo hat cultural symbols based on fractal theory and style migration can play a certain role in promoting cultural inheritance.

*Keywords:* Fractal geometry, iterative function system, style migration, rattan art design

## 1. Introduction

Traditional handicraft is the crystallization of the wisdom of the Chinese nation's production and life, and it is an important part of "Intangible Cultural Heritage", as well as an important part of the excellent traditional culture of the Chinese nation. Rattan weaving, as a national intangible cultural heritage, originated from Huaiyuan rattan weaving and Hanzhong rattan weaving in China [1-4]. Huaiyuan rattan weaving is located in Chongzhou City, Chengdu City, Sichuan Province, while Hanzhong rattan weaving is located in Nanzheng District, Hanzhong City, Shaanxi Province. This

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traditional craft utilizes mountain rattan to weave a variety of beautiful woven products, including a variety of utensils and furniture, and has a long history and deep cultural heritage [5-8]. The technique of rattan weaving has a long history and has been handed down for thousands of years, becoming an important part of many cultures around the world [9-10].

The Maonan is a less populous ethnic group in China, and is also one of the three endemic ethnic groups in Guangxi. The Maonan have created their own unique and splendid culture, such as the Maonan fat set, the Dragon Sculpture Festival, stone carvings, etc., and the Maonan flower bamboo hat culture is one of their representative cultures [11-14]. Flower bamboo hat, known as “top card flower” in Maonan language, is a love object for Maonan young people to talk about love, and has a beautiful legend, which is a cultural symbol of Maonan [15-16]. With the development of the times, the traditional inheritance mode of flower bamboo hat is both single and boring, the scope of inheritance becomes smaller, gradually eliminated by the times, only to follow the footsteps of the times, change the management thinking, borrowing the relevant platform, weaving skills into other industrial development [17-20], as well as cultivate new teaching concepts and skills of the inheritors and skills of the development of the new mode of use, into the current market demand, pulling the economic development of the region, etc., in order to promote the flower bamboo hat skills, the Maonan youth love affair, and has a beautiful legend, is the cultural symbol of the Maonan people [15-16]. In order to promote the self-protection and inheritance of flower and bamboo hats, etc. [21-23].

In this paper, the application of digital design method in the innovative design of rattan weaving art is studied. Based on the fractal theory, the three-dimensionalization of the two-dimensional fractal is completed by constructing the two-dimensional representation to increase the external visual effect, which realizes the preliminary innovative design of rattan weaving art form. And then by combining the GrabCut algorithm and VGG16 neural network, the local style migration of the pattern of cultural and creative products was realized. Using GrabCut algorithm to cut the content image of the Maonan flower bamboo hat cultural and creative products to determine the main region of style migration. The image of the region is binarized to generate a mask map, and the image of the white region in the image is extracted, and its mask matrix is extracted and condensed. The mask matrix is input into the channel of style migration to realize the style migration of the pattern containing the cultural symbol elements of the Maonan flower bamboo hats, further realizing the innovation of the art form of rattan weaving. Example verification and questionnaire survey are carried out, which proves that the method of this paper can create artistic cultural and creative products, which is conducive to the inheritance of folk culture.

## 2. The innovation of rattan weaving art design form based on fractal geometry

### 2.1. *Mathematical foundations of fractal geometry*

Fractal geometry is the basis for the study of fractal theory. Measure and dimension are the most fundamental mathematical concepts in fractal theory and applications.

Hausdorff measure [24] is defined, let $U$ be the set to be measured if $U$ is any nonempty subset in a $n$-dimensional Euclidean space $R^n$, and the diameter of $U$ is defined as $|U| = \sup\{|x-y| : x, y \in U\}$, i.e., the maximum value of the distance between any two points within $U$.

If $\{U_i\}$ is the class of sets covering $F$ formed by a countable (or finite) number of sets with diameters not exceeding $\delta$, i.e., let $F$ be an arbitrary subset of $R^n$, $s$ be a nonnegative real number, and $|U|$ be the diameter of an arbitrary nonempty subset $U$ in an $n$-dimensional Euclidean space $R^n$. Then:

$$H^s(F) = \lim_{\delta \to 0} H_s^s(F) \quad \text{is called the } s\text{-dimensional Hausdorff measure of } F \tag{1}$$

For any subset $F$ of $R_n$ and the real constant $\delta < 1$, $H_\delta^s(F)$ is a reduced function of $s$, so $H^s(F)$ is also a reduced function, i.e., the following conclusion holds: if $s < t$ and $\{U_i\}$ are a $\delta-$ cover of $F$, there:

$$H_s^t(F) \leq \sum_i |U_i|^t \leq \delta^{t-s} \sum_i |U_i|^s \tag{2}$$

Therefore, taking the lower bound of certainty to $H_\delta^t(F) \leq \delta^{t-s} H_\delta^s(F)$, and making $\delta \to 0$, it follows that if $H^s(F) < \infty$, there is $H^t(F) = 0$ for $s < t$. Therefore, there exists $s$ a critical value at the point where $H^s(F)$ jumps from $\infty$ to 0. This critical value is called the hausdorff dimension of $F$, denoted $\dim_H F$, and often denoted $D_H$. Formally:

$$\dim_H F = \inf\{s : H^s(F) = 0\} = \sup\{s : H^s(F) = \infty\} \tag{3}$$

Therefore:

$$H^s(F) = \begin{cases} \infty(If\ s < \dim_H F) \\ 0(If\ s > \dim_H F) \end{cases} \tag{4}$$

The box dimension is a widely used dimension that is relatively simple to compute compared to the Hausdorff dimension.

Partitioning the rectangle into a number of small rectangles of side length $\varepsilon$, so that necessarily some small rectangles contain points in $F$. Denote by $N(\varepsilon)$ the number of small moments that contain all the points in $F$. The box dimension $D_b$ of $F$ is defined as:

$$D_b(F) = \lim_{\varepsilon \to 0} \left( \frac{\ln N(\varepsilon)}{\ln(1/\varepsilon)} \right) \tag{5}$$

The capacity dimension $D_c$, and let any bounded subset $F$ of $R^n$, is defined as the capacity dimension $D_c$ of $F$ when covering $F$ with a $n$-dimensional ball of radius $\varepsilon$, assuming that $N(\varepsilon)$ is the minimum of the number of balls:

$$D_c(F) = \lim_{\varepsilon \to 0} \left( \frac{\ln N(\varepsilon)}{\ln N(1/\varepsilon)} \right) \tag{6}$$

Similarity dimension $D_s$, let any bounded subset $F$ in $R^n$, as long as the local enlargement of a certain number of times can always be obtained with the overall consistent graph, then called $F$ for self-similar set. For the self-similar set $F$, define the similarity dimension $D_s$ as:

$$D_s(F) = \frac{\ln m}{\ln(1/c)} \tag{7}$$

The information dimension $D_i$, given any bounded subset $F$ of $R^n$, always finds a $n$-dimensional rectangle such that $F$ is contained in this rectangle. Divide the rectangle into $N(\varepsilon)$ small rectangles of side length $\varepsilon$, and remember that $p_i$ is the probability that the point in $F$ falls in the $i$th small rectangle, then the information dimension $D_i$ of $F$ is defined as:

$$D_i(F) = \lim_{\varepsilon \to 0} \left( \frac{I(\varepsilon)}{\ln(1/\varepsilon)} \right) \tag{8}$$

Among them:

$$I(\varepsilon) = \sum_{i=1}^{N(\varepsilon)} p_i \ln\left(\frac{1}{p_i}\right) \tag{9}$$

The association dimension $D$, in order to study the association of any two points $y_i$ and $y_j$ in m-dimensional space, consider their "distance": $r_{ij} = \left|y_i - y_j\right|$. Define the association dimension $D$ as:

$$D = \lim_{\varepsilon \to 0} \frac{\ln C(\varepsilon)}{\ln \varepsilon} \tag{10}$$

Although there are various definitions of the fractal dimension, they are basically based on the idea of "variable scale $\varepsilon$ – coverage", where each measurement is made by ignoring irregularities smaller than $\varepsilon$ and considering the condition of the measurement value when $\varepsilon \to 0$, so that a unified definition of the fractal dimension can be given $D_q$:

$$D_q = \lim_{\varepsilon \to 0} \lim_{q_i \to q} \frac{1}{q_i - 1} \frac{\ln \sum_{i=1}^{N(\varepsilon)} p_i^{q_i}}{\ln \varepsilon} \tag{11}$$

Similarity principle, let the self-similar set $F$ consist of $n$ non-overlapping subsets $F_i\left(i = 1, 2, 3, \ldots, n\right)$, which are called uniformly self-similar fractal sets when each subset has the same reduction ratio $r_i = r\left(i = 1, 2, 3, \ldots, n\right)$. Its fractal dimension is:

$$D_f(F) = \frac{\ln n}{\ln\left(1/r\right)} \tag{12}$$

Addition and summation principle, if the intersection of two fractal sets $F_1$ and $F_2$ is $F$, then the dimension of $F$ is:

$$D(F) = D\left(F_1\right) + D\left(F_2\right) - d \tag{13}$$

The product-sum principle, which assumes that the fractal set $F$ is the product of two non-overlapping fractal subsets $F_1$ and $F_2$, makes the dimension of $F$ equal to the sum of the dimensions of $F_1$ and $F_2$:

$$D\left(F\right) = D\left(F_1\right) + D\left(F_2\right) \tag{14}$$

The sum and concatenation principle, let fractal set $F$ be the sum of two mutually unrelated fractal subsets $F_a$ and $F_b$, two fractal subsets with dimensions $D\left(F_a\right)$ and $D\left(F_b\right)$ and $D\left(F_a\right) > D\left(F_b\right)$, respectively, then $F$ has dimension $D\left(F_a\right)$.

The matching principle, for fractal sets $F_1$ and $F_2$ to effectively form fractal set $F$, requires that the fractal dimensions of $F_1$ and $F_2$ be equal or locally equal.

The hierarchy principle, where a fractal whole is a fractal set $F$, $F$ consists of fractal subsets $F_i(i = 1, 2, 3, \ldots, n)$ belonging to different levels, i called levels. $F_i$ is in some way similar to $F$. The smaller $i$ is, the simpler it is; $i$ the larger it is, the more complex the structure.

$L$ The mathematical model of the system is the Fibonacci series, and this relationship can be expressed by the following recursive formula:

$$F_{n+2} = F_{n+1} + F_n \tag{15}$$

We consider a string of two letters $a$ and $b$ called a word. $a, b$ may occur several times in the same word. Each letter is associated with a rewriting rule.

$L$ The system generation rule, $L$ system is a formal language that centers on the string generation algorithm.

Draw the flowchart of the $L$ system generation algorithm as shown in Fig. 1:

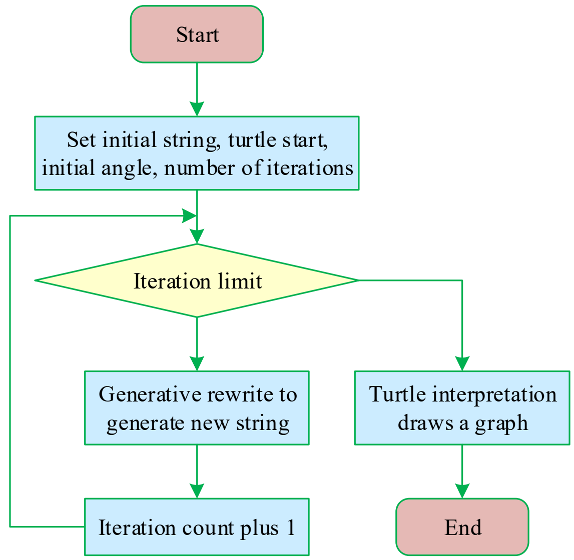


**Fig. 1.** Flowchart of system generation algorithm

An Iterated Function System (IFS) [25] is a fractal construction system: fractals have local and global self-similarity, and an affine transformation in mathematics is a linear transformation that happens to have the property of scaling a graph up, down, rotating and translating it. In principle, any graph can be described or generated by a set of affine transformations.

There are two types of iterative algorithms for generating IFS attractor sets: one is deterministic iterative algorithm and the other is randomized iterative algorithm.

1) Deterministic iterative algorithm. Set $\left\{R^2 : w_1, w_2, \cdots\cdots, w_N\right\}$ to be IFS and select $A \subset R^2$ to be based on:

$$A_{n+1} = \hat{Y}_{j=1}^{n} w_j\left(A_n\right) n = 1, 2, \cdots\cdots \tag{16}$$

Recursively computing $A_n = w^n\left(A\right)$, sequence $\left\{A_n\right\}$ converges to the attractor of the IFS, the fractal graph.

Deterministic algorithms require more storage space, so usual IFS implementations do not use deterministic algorithms.

2) Randomized Iterative Algorithm. Let the IFS with probability consist of a set of compressed affine transformations $\left\{R^2 : w_1, w_2, \cdots\cdots, w_N\right\}$ and a probability set $\left\{p_1, p_2, \cdots\cdots, p_N\right\}$. Where:

$$\sum_{j=1}^{N} p_j = 1,\ And\ p_j > 0, j = 1, 2 \ldots\ldots N \tag{17}$$

$$w_j\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a_j & b_j \\ c_j & d_j \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} e_j \\ f_j \end{pmatrix}, j = 1, 2, \cdots\cdots, N \tag{18}$$

Let $\varphi$ be an operator whose domains of definition and value are in the same metric space, then $x = \varphi(x)$ the solution of such an equation is called the immovable point corresponding to operator $\varphi$. In affine transformations, the initial point $\left(x_0, y_0\right)$ can be chosen with immovable points, which ensures that the initial point is in the final fractal graph.

Then:

$$\begin{pmatrix} x_0 \\ y_0 \end{pmatrix} = w_j \begin{pmatrix} x_0 \\ y_0 \end{pmatrix} = \begin{pmatrix} a_j & b_j \\ c_j & d_j \end{pmatrix} \begin{pmatrix} x_0 \\ y_0 \end{pmatrix} + \begin{pmatrix} e_j \\ f_j \end{pmatrix} \tag{19}$$

I.e., seek a solution:

$$\begin{pmatrix} a_j - 1 & b_j \\ c_j & d_j - 1 \end{pmatrix} \begin{pmatrix} x_0 \\ y_0 \end{pmatrix} = \begin{pmatrix} -e_j \\ -f_j \end{pmatrix} \tag{20}$$

The preferred option for the process of visualizing fractal graphs through the computer is to use a library of three-dimensional graphing functions, which is more computationally efficient but more work intensive.

The second option is to utilize off-the-shelf fractal graphics software packages, which make it easier to see the general results of some new ideas.

The third option is to utilize general-purpose graphics processing software, such as AUTOCAD, which has powerful 3D modeling capabilities and the ability to draw realistic-looking graphics. This feature provides a better visualization environment for fractal graphics experiments.

The fourth option is to use the 3D modeling engine ACIS, which is the method used in this paper.

1) Modeling Nature. The simulation of natural scenery is an important element in the computer generation of fractals. The combination of fractal theory and computer graphics can draw realistic pictures.

2) Fractal interpolation. The traditional interpolation method of “straight instead of curved” is obviously not a good approximation for a large number of actual coastlines, heart and brain wave maps, stock price curves, etc., because these curves are continuous but non-smooth, and are not conductive almost everywhere.

3) Military. The fractal model of topography can fully reflect the statistical texture characteristics of the terrain, so it can be used to fit the low-resolution data, extract the characteristic parameters, and carry out fractal interpolation, so as to obtain the high-resolution data and effectively apply it in the guidance technology.

4) Computer Art. The use of fractal self-similarity, you can construct a variety and high-resolution art patterns, you can draw a lot of beautiful images, has a high value of art appreciation, such as the design of wallpaper, cloth patterns, the production of postal postcards and so on.

### *2.2. Rattan weaving art form innovation design process*

In the overall process of parametric design of rattan art form product morphology, the Grasshopper plug-in is used to establish a parametric design model and adjust the basic parameters of the design. After determining the logical structure of the art product data, according to the corresponding parameter modification to achieve a more advanced and complicated logic modeling instructions, and this rationalization of the logic into a visual visual whole, to generate dynamic morphology analysis, to observe the changes in the product morphology, each step can be modified according to the needs of the product design of the fractal parameters, adjusting the details of the design, and ultimately find out the optimal form for the optimization of the details of the art product. This design process takes parametric design as the core to develop the product form design, which improves the design efficiency, shortens the development cycle and ensures the effectiveness of the design. The design process of parameterized product form is shown in Figure 2, which is realized in two steps: two-dimensional and three-dimensional.

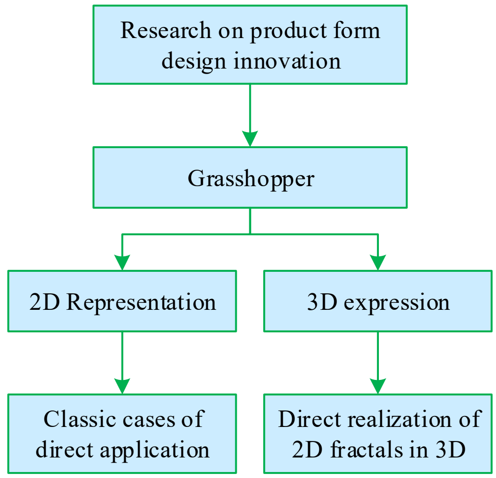


**Fig. 2.** Parametric design process

Two-dimensional expression: Taking the product form and technological innovation as the basic carrier, the classic image of fractal is directly applied to the rattan art product form design, i.e., through the basic design means of decomposition and reorganization, the fractal graphic is directly applied to the unit body of the rattan art product modeling and through the regular combinations of the unit, so as to make it into a whole. Adopting fractal algorithm model for two-dimensional product appearance expression, the generated multiple two-dimensional fractal patterns are applied to other details processing of rattan weaving art product morphology design, which increases the external visual effect and the innovative ideas of three-dimensional realization.

Three-dimensional expression: directly realize the three-dimensionalization of two-dimensional fractal, and innovate on the basis of the original fractal, refine, deform and other abstract generalization of the characteristics of the fractal image, and apply them to the construction and combination of the product form, so as to achieve to meet the functional requirements of rattan weaving art products and the overall law of design. Adopting the fractal algorithm for the optimal design of the shape of rattan weaving art products maximizes the innovative characteristics of rattan weaving art products, realizes the three-dimensional diversified ethnic grouping system, and applies the innovative technology to the inheritance of the cultural symbols of the Maonan Flowering Bamboo Hat to open up a new road for the design of its cultural and creative products, so as to promote the inheritance of the cultural symbols of the Maonan Flowering Bamboo Hat.

## 3. Graphic rendering of rattan flower and bamboo hat elements based on style migration

### *3.1. Rendering Methods for Localized Style Migration of Patterns*

This chapter proposes a digital rendering method for pattern local style migration, through the combination of GrabCut algorithm [26] and VGG16 neural network [27], so as to realize pattern local style migration. The specific implementation process of this digital rendering method can be divided into the following 3 steps: in the first step, the content image is cut using the GrabCut algorithm, which is used to determine the region of style migration, in the second step, the cut image is binarized to generate the mask image, the content image corresponding to the white region of the mask image will be subjected to style migration, and the content image corresponding to the black region will be kept unchanged. In the third step, the mask matrix is extracted from the mask image and input into the feature channel of the style migration, so as to realize the local style migration of the pattern.

### *3.2. Rattan Flower Bamboo Hat Rattan Flower Bamboo Hat Pattern Style Simulation*

The rattan flower and bamboo hat pattern style migration simulation is divided into the following 3 steps: in the first step, the image segmentation of the content pattern of the style migration is performed to separate the foreground image from the background image. In the second step, the segmented pattern is binarized to generate a mask map. In the third step, the mask information is extracted from the mask map, and the local style migration of the image is realized by controlling the region of the image style migration through the mask information and the guidance matrix.

The foreground pattern of the content image is separated from the background pattern using the GrabCut image segmentation algorithm.GrabCut5s1 is an improved version of GraphCut, which makes use of the texture information and boundary information, or color|information and contrast information in the image, and with a small amount of user interaction can get a better segmentation result. The segmentation result of the content image can be obtained by first selecting the pattern to be segmented using a rectangle in the content image, based on which the boundary of the image segmentation is determined.

Image segmentation is performed on the content image of the style migration. As the content image only needs to separate out the foreground and background 2 regions, the mask image also needs only two regions can be, and after the image segmentation of the resultant image background are black, so the resultant image is binarized:

$$S = T\left(r\right) = 255,\ If\ \ r \neq 0 \tag{21}$$

In this paper, the VGG16 network model is used, which has a simple and moderately computational structure.The network structure of the VGG16 model is subdivided into 16 layers, including 13 convolutional layers, 3 fully connected layers and 5 pooling layers.

The original VGG16 network model is initially used for object classification and recognition, where the image is first input, the features of the image are computed through a multilayer convolutional network, and finally the predicted values are output through the fully connected layers. Using VGG16 for image style migration, the content image and style image are first input, the content features and style features are computed by multilayer convolutional network, and then the resultant image after stylization of the content image is finally output by reducing the difference between the random white noise image and the style image. Using the VGG16 network model for image style migration, the last 3 fully connected layers are not used, so the VGG16 network model can be built by deleting the last 3 fully connected layers.

After building the VGG16 network model for feature extraction for style migration, the content image, the style image and the content mask map are simultaneously input into the VGG16 network for extracting the content features and style features, and calculating the content loss value, the style loss value, and the total variance loss value. Where the content loss function is applied to calculate the content loss value of conv5 convolutional layer groups, the style loss function is applied to calculate the style loss value of each convolutional layer group, the total variance loss function is applied to calculate the total variance loss value of the random white noise image (i.e., the image to be generated), and finally the total loss value is calculated.

A graphic rendering method based on style migration is proposed, so that the image to be generated not only retains the semantic information such as spatial information and shape edges of the content image, but also finely integrates the color features and texture features of the style image.

1) Total loss function. In order to make the image to be generated retain both the content of the content image and the style of the style image, let $\vec{p}$ be the content image, $\vec{a}$ be the style image, and $\vec{x}$ be the random white noise image (i.e., the image to be generated). The VGG16 network model is used as a feature extractor for extracting content features and style features, calculating the content loss value, style loss value and total variance loss value, and defining the total loss function as follows:

$$L_{total}\left(\vec{p},\vec{a},\vec{x}\right)=\alpha L_{content}\left(\vec{p},\vec{x}\right)+\beta L_{style}\left(\vec{a},\vec{x}\right) +\gamma L_{total\_variation}\left(\vec{x}\right) \tag{22}$$

A series of images with different degrees of style migration can be generated by varying the values of $\alpha/\beta$ and $\gamma$. Meanwhile, the convolutional layer conv5_2 is selected to calculate the content loss; the convolutional layers conv1_1, conv2_1, conv3_1, conv4_1, conv5_1 are selected to calculate the style loss, in which the weight value $w_l$ of each convolutional layer is $\frac{1}{5}$, and the white noise image is selected to calculate the total variance loss.

2) Content loss function. Image local style migration needs to retain the content features such as structural information and positional relationship of the part to be migrated in the content image, the content features of the content image are extracted by VGG16 network, and the white noise image is continuously optimized to reduce the difference between the two. The content image is processed by the convolutional network, and each convolutional layer obtains a set of intermediate vectors, which are called feature maps. The set of feature maps formed by these feature maps is the content feature set.

Let $\vec{p}$ be the content image, which is also recoded by each convolutional layer of the VGG16 network. $P^l$ and $F^l$ denote their content features in layer 1, respectively. From this, the content loss function and its derivation can be defined as follows:

$$L_{content}\left(\vec{p},\vec{x},l\right)=\frac{1}{2}\sum_{i,j}\left(F_{ij}^l-P_{ij}^l\right)^2 \tag{23}$$

$$\frac{\partial L_{content}}{\partial F_{ij}^l}=\begin{cases}\left(F^l-P^l\right)_{ij}, \mathit{If}\ F_{ij}^l>0\\ 0, \mathit{If}\ F_{ij}^l<0\end{cases} \tag{24}$$

3) Style loss function. The local style migration of the image is controlled by the mask information of the mask map, and the spatial bootstrap feature map is introduced to control the region of style migration. Definition $T_r^l$ is the bootstrap channel of the layer 1 feature matrix, which is the feature map of each layer in the VGG16 network multiplied by $R$ bootstrap channels, i.e., the mask information of the mask map is multiplied by the feature information of the style map by element, as follows:

$$F_r^l(x)=T_r^l \odot F^l(x) \tag{25}$$

The image style is defined as the correlation coefficient of the activation terms between the individual channels of a particular layer of the VGG16 network, and the Gram matrix is used to measure the similarity of the output results of each layer of the VGG16. The bootstrapped Gram matrix with mask information is obtained by computing the inner product of each channel $F_r^l$, denoted as $G_r^l(x)$, as follows:

$$G_{rij}^l(x)=\sum_k F_{rik}^l(x)^T F_{rjk}^l(x) \tag{26}$$

where $G_{rij}^l \in R^{N_l\times M_l}$, $G_{rij}^l$ denote the product of the random white noise image with the output activation term of the $i$ rd convolutional kernel and the $j$ th convolutional kernel in layer 1 of the VGG16 network.

Let $\vec{a}$ and $\vec{x}$ denote the stylized image and the random white noise image, respectively, and $A^l$ and $G^l$ are their bootstrapped Gram matrices in layer 1, respectively. From this, the style loss function of layer 1 can be defined as

$$E_{rl} = \frac{1}{4N_l^2 M_l^2} \sum_{i,j} \left( G_{rij}^l - A_{rij}^l \right)^2 \tag{27}$$

Based on the weights of different sets of convolutional layers the overall style loss function can be defined as:

$$L_{style}(\vec{a}, \vec{x}, l) = \sum_{l=0}^{L} w_l E_{rl} \tag{28}$$

where $w_l$ represents the weight of each layer of style loss in VGG16.
4) Total Variation Loss Function. TV is a commonly used variate, and its role in the image style migration process is to maintain the smoothness of the image and eliminate the artifacts that may be brought about by image restoration. Let $\vec{x}$ denote a random white noise image, and $x_{i,j}^l$ the $j$th element of the $i$th row of the feature map of the image to be generated in layer 1 of the VGG16 network. From this, the total variational loss function can be defined as:

$$L_{total\_variation}(\vec{x}, l) = \sum_{i,j} \left( \left( x_{i,j+1}^l - x_{i,j}^l \right)^2 + \left( x_{i+1,j}^l - x_{i,j}^l \right)^2 \right)^{\delta/2} \tag{29}$$

## 4. Innovation of rattan weaving art form and inheritance of cultural symbols of flower bamboo hats

### *4.1. Rattan weaving art design form innovation generation*

4.1.1. L-Iterative Realizations. The Koch curve is a single-rule L-system, and the setting of the three parameter values can generate a series of Koch curve graphs, and the parameter settings are shown in Table 1. Starting from the initial coordinates (0,0), each walk is the length of F, the rotation angle is set to 60°, and it is converted into radians, the string F$ is searched, and the character F is replaced with the expression F-F++F-F to generate a new string F$, in the process of generating a new string, if "+" is encountered, it is rotated 60° counterclockwise, if it encounters "-", it rotates clockwise, and when it encounters "F", a straight line is drawn along the current direction until the end of the string, The Koch curve was drawn.

**Table 1.** L-systems (Koch Curve) Parameters

| | Rotation Angle | Initial axiom | Generating rule |
|---|---|---|---|
| Koch | 60° | F | F-F++F-F |
| Koch snow | 60° | F++F++F | F-F++F-F-F |
| Koch triangle | 60° | F--F--F | F-F++F-F |
| Koch square | 90° | F+F+F+F | F+F-F-FFF+F+F-F |

For fractal graphs like Koch curves that are generated by a single regular L-system grammar, there are no breakpoints and no redrawn or crossed line segments. Graphs like fractal trees can also be generated by the L-system grammar, which generally utilizes the stacking symbol "[" and the stacking symbol "]" to set the location of breakpoints. Figure 3 shows a fractal tree, is the use of "[" and "]" to set the breakpoints, and the graphics generated. Fractal tree has a very regular form of symmetry, it is the main trunk in the center as the standard axis of symmetry, the branches on both sides have a strict form of balance and symmetry. Fractal tree construction is from the root, gradually radiate upward, and finally form the shape of a tree, this construction method can also be grafted onto the design of the Maonan flower bamboo hat, choose a starting point on the brim, from here on up to the other parts of the fractal tree to the generation of the radioactive design of the graphic, so that the hat has a unified design of the overall nature of the hat, giving a sense of wholeness. This image element is not a simple superposition of fractal patterns, but a recursive continuous state.

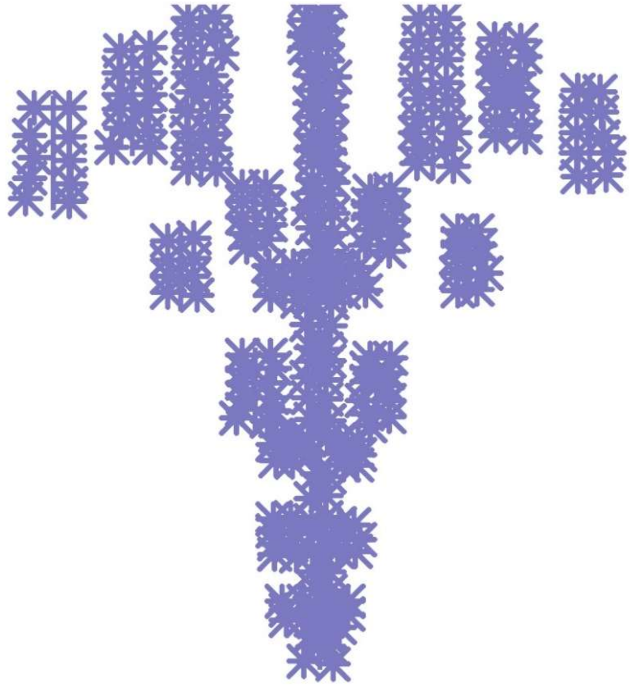

**Fig. 3.** Fractal Tree

In addition to single-rule L-system grammars, there are also multi-rule L-system grammars. Multi-rule L-system grammars have two kinds of cases, one is that the characters in the grammars are only used as replaced characters and not as drawing characters, and the other is that the characters in the grammars are used as both replaced characters and drawing characters. Figure 4 shows the Peano curve and its variation graph, which is the multi-regular L-system fractal graph. The values of its individual parameters are shown in Table 2.

Both single L-system grammars and multi-rule L-systems take values of the rotation angle between 0 and 360°. The initial axioms and the generation storage rules are composed of strings, where the initial axioms take the range of string arrays, and for the generation rules they take the range of string arrays and the values of "+, - " and the set of "[" and "]". By defining different strings, different L-system fractal graphs can be drawn.The L-system algorithm is only a simple implementation of the graph. If the fractal graphs are to be perfected in the innovative design of rattan weaving art, the color palette and its animation techniques can also be used to form a natural excess of colors in the scene.

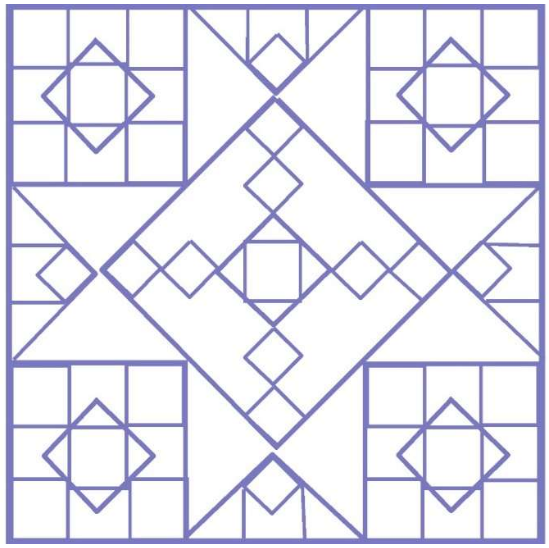

**Fig. 4.** Peano Curve Graphics

**Table 2.** Peano Curve and Change Graphics Parameters

| Rotation Angle | Initial axiom | Generating rule |
|---|---|---|
| 90° | X, Y | -YF+XFX+FY-, +XF-YFY-FX+ |
| 90° | F-F-F-F | F[F]-F+F[--F]+F-F |

4.1.2. IFS Iterative Realization. Each ISF code is a set of affine transformations, there is no restriction on the values of the six parameters a, b, c, d, e, f, which can be any Double type data, p is the probability that each affine transformation is not called, which is a real number between 0 and 1. The process of IFS algorithm is the same as that of a photo developing in a developer solution, the image will be clearer and clearer, and finally all of the image will be displayed. The key to generate graphs by IFS method is to find out the IFS code, for a graph we can use its obvious geometric relationship to determine the IFS code. Figures 5 and 6 show the graphs generated by a set of IFS code after 10,000 and 50,000 fractal iterations, respectively. The more the number of iterations of the graph, the more clearly the composition of the graph is visible. The irregular snowflake pattern is generated by the iteration of affine transformation, the graphic can be said to be composed of many small irregular snowflakes collage, the composition of these irregular snowflakes has a certain degree of regularity, can be applied to knitted garments, to play a kind of casual, close to the natural life of the effect. It can also be used as a tool for passing on the traditional cultural symbols of Maonan flower bamboo hats, such as the patterns of tie-dye, batik and blue print.

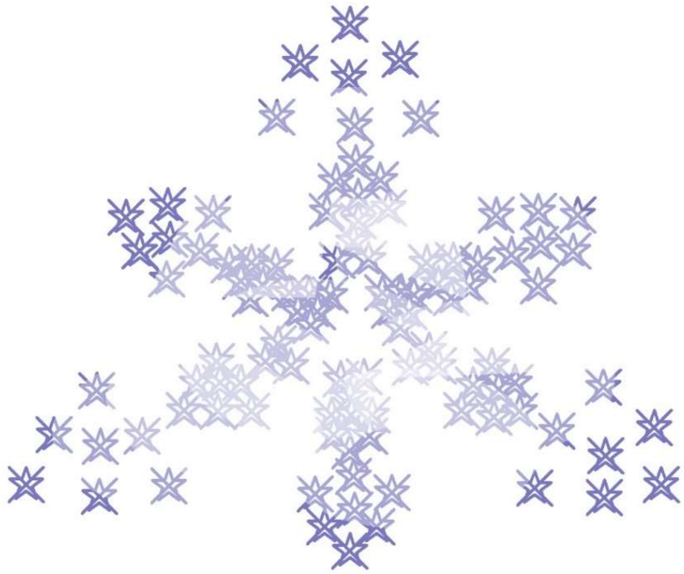

**Fig. 5.** The figure generated by the 10000 subfractal iteration

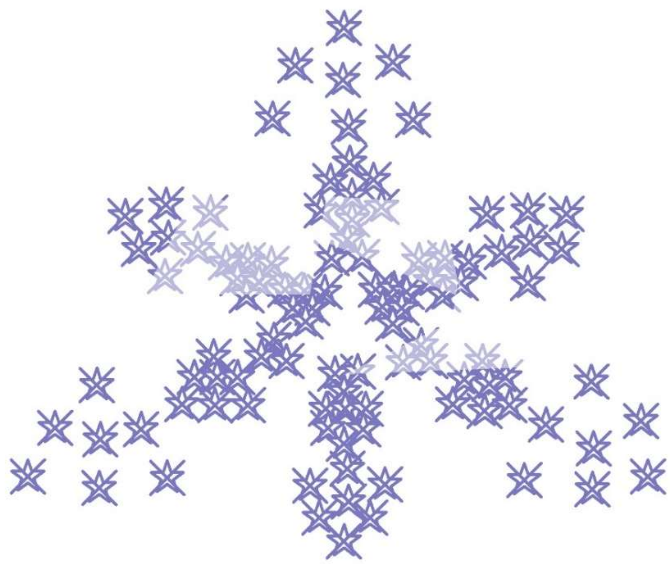

**Fig. 6.** The figure generated by the 50000 subfractal iteration

### *4.2. Perception of the inheritance of cultural symbols of Hua Zhu Hat*

According to the extensive collection and organization of IPA samples of Maonan ethnic flower bamboo hat cultural symbol products in this paper, designers can integrate the elements of the flower bamboo hat into other rattan art products, such as sunshade hats, handbags, handkerchiefs and so on. To analyze the morphological characteristics and similarities of the samples of the above three types of products, in order to facilitate the reconstruction experiments of the morphological perception samples of the Maonan Flower Bamboo Hat Cultural Symbol Product, this study, based on the morphology of the representative samples in the previous period and their results, coded the corresponding styling elements, i.e., sunshade hats, handbags, and handkerchiefs, with letters A, B, and C respectively, and categorized the design categories of different morphologies in each design project into commonality and individuality two categories, and the numbers 1-1, 2-1, 2-2 and 3-1 are used for auxiliary coding. Table 3 shows the coding results of the product form elements of the Maonan flower bamboo hat cultural symbol.

Based on Table 3, we create the coding table of the product form elements of sun hat, handbag and handkerchief to provide the corresponding reasoning solutions for their form design, and the element design model of the sun hat product form contains all the relevant common and individual form element categories. The elemental design model of the handbag product form contains all relevant common and individualized form elements except AC1-1 and AC2-1. The elemental design model for the Handkerchief product form contains all relevant common and individual form element categories.

**Table 3.** Product IPA form element code list

| Cultural symbol products | Commonales | Personality class |
|---|---|---|
| A | AC1-1, ABC1-2, ABC1-3, AC2-1, ABC4-1, ABC4-2, AB6-1, AB6-2, ABC2-1, ABC2-2 | A3-1, A3-2, A5-1, A5-2, A7-1, A7-2 |
| B | | B1-1, B1-2, B2-1, B2-2 |
| C | | C1-1, C1-2, C2-1, C2-2 |

People from multiple fields were selected to form the group of subjects to ensure the generalizability and high reliability of the questionnaire results. A total of 70 subjects were selected. In order to satisfy the readability of the questionnaire, so that the subjects can have a more precise judgment on the understanding of the Maonan Flower Bamboo Hat Cultural Symbol Product Image Retrieval, this questionnaire replaces the word “design” with “like”, so that the subjects can think from the angle of their personal understanding, and then complete the questionnaire. Completion of the questionnaire The purpose of the questionnaire design is to ask the subjects, as a consumer of the Maonan flower bamboo hat cultural symbol product, to combine their own preferences for the Maonan flower bamboo hat culture, to conceptualize a Maonan flower bamboo hat cultural symbol product design plan that meets the different needs of the individual (degree of design, “very like, like, general”) and to select the design plans in the above coding table. The design solutions were selected from the above coding table and reassembled into the ideal product that meets the individual needs of the subjects.

A total of 70 questionnaires were distributed in this survey, and 70 basic valid questionnaires were initially recovered. Only some of the individual subjects' questionnaires were not filled in with their names and ages, etc., therefore, 60 valid questionnaires were finalized as a sample set of data for statistics. The 60 valid questionnaires were counted, and the results of the morphological preference survey of sunshade hats, handbags, and handkerchiefs are shown in Tables 4 to 6, which statistically show the subjects' choices of very favorite, favorite, and general Maonan flower bamboo hats as cultural symbols of the products.

**Table 4.** Shading preference survey selection results

| | Very dislike | Dislike | General | Like | Very fond of |
|---|---|---|---|---|---|
| A1 | 3 | 5 | 14 | 18 | 20 |
| A2 | 4 | 17 | 32 | 6 | 1 |
| A3 | 1 | 4 | 13 | 27 | 15 |
| A4 | 1 | 3 | 12 | 26 | 18 |
| A5 | 15 | 22 | 15 | 6 | 2 |

**Table 5.** Selection results of handbags' preference survey

| | Very dislike | Dislike | General | Like | Very fond of |
|---|---|---|---|---|---|
| B1 | 4 | 8 | 4 | 22 | 12 |
| B2 | 12 | 24 | 22 | 2 | 0 |
| B3 | 7 | 14 | 13 | 19 | 7 |

| | | | | | |
|---|---|---|---|---|---|
| B4 | 7 | 18 | 12 | 13 | 10 |
| B5 | 3 | 14 | 21 | 12 | 10 |
| B6 | 12 | 24 | 15 | 7 | 2 |
| B7 | 0 | 10 | 15 | 17 | 18 |
| B8 | 0 | 8 | 15 | 21 | 16 |

**Table 6.** The handkerchief form preference survey selection results

| | Very dislike | Dislike | General | Like | Very fond of |
|---|---|---|---|---|---|
| C1 | 4 | 8 | 28 | 12 | 8 |
| C2 | 0 | 6 | 15 | 24 | 15 |
| C3 | 1 | 8 | 13 | 21 | 17 |
| C4 | 1 | 18 | 28 | 8 | 4 |
| C5 | 13 | 17 | 19 | 9 | 2 |
| C6 | 5 | 17 | 28 | 10 | 0 |
| C7 | 0 | 4 | 18 | 17 | 21 |
| C8 | 14 | 29 | 15 | 1 | 1 |

Maonan flower bamboo hat cultural symbols product form features need to be combined with product form elements will be analyzed, can be found in different preferences of the Maonan flower bamboo hat cultural symbols product form has its typical characteristics, this paper selects the characteristics of the more obvious high preference for modeling and low preference for modeling to analyze the characteristics of the analysis.

Figures 7-9 show the distribution of high preference modeling features of sun hat, handbag and handkerchief respectively, i.e. “very much like” in the Maonan Hanazhu Hat cultural symbols product morphology features. Among the sun hats, A1 and A3 are highly preferred in terms of aesthetics, of which ABC4-1, AB6-1, ABC2-2 and A7-1 are their common features. The morphology of B7, B8 and B9 in Handbag is popular, where ABC4-1, AB6-1, ABC2-2, B1-1 and B2-2 are its common features. The aesthetics of the forms C2, C4 and C7 in the Handkerchief are popular, where ABC4-2, BC2-1, C1-2 and C2-1 are its shared features.

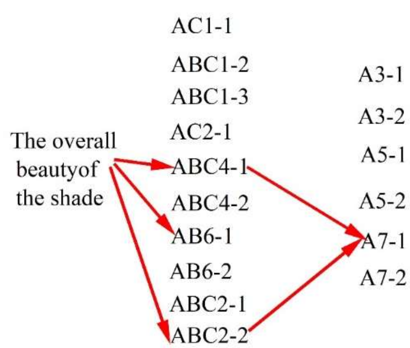


**Fig. 7.** The height preference of the shade is high

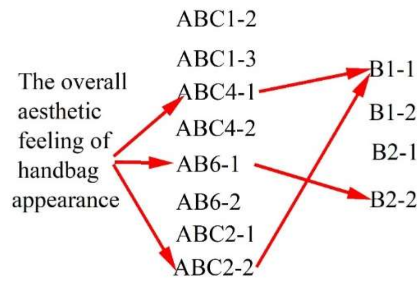


**Fig. 8.** The handbag form is high preferred for the characteristics of the shape

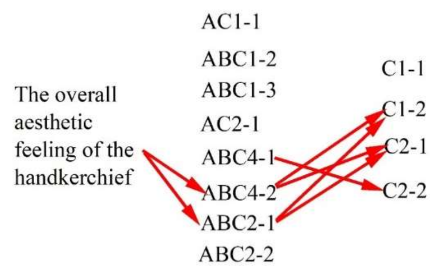


**Fig. 9.** The handkerchief form high preference modelling characteristics

Figure 10-Figure 12 shows the distribution of low-preference modeling features of sun hat, handbag and handkerchief respectively, i.e., “disliked” in the Maonan flower and bamboo hat cultural symbols of the product morphology features. Among the handkerchiefs, C3 and C8 have low aesthetic appeal, of which ABC4-2 and C2-1 are their common features. The morphological aesthetics of B4 and B6 in the handbag are low, of which, ABC1-3, ABC4-1, AB6-1, ABC2-2 and B2-2 are their common features. Low morphological aesthetics of A2 in the sun hat, of which ABC1-2, ABC4-2, AB6-1, ABC2-2 and A7-1 are its shared features.

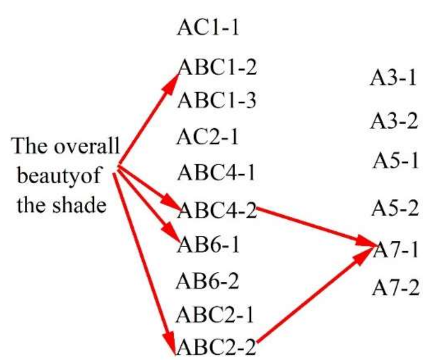


**Fig. 10.** The low preference of the shade is characterized by low preference

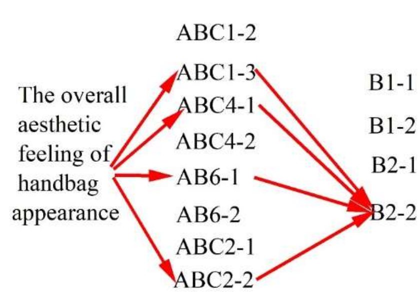


**Fig. 11.** The style of handbag is characterized by low preference

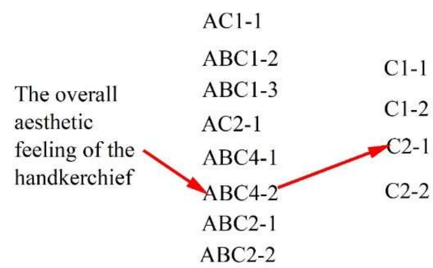


**Fig. 12.** The handkerchief form low preference modelling feature

Combining the objective quantitative results of the product form design examples of the Maonan flower bamboo hat culture symbols in this chapter and the results of the questionnaire experiment, the sunshade hat, the handbag and the handkerchief are analyzed and compared respectively, and the comparison results are shown in Table 7. Comparative analysis of the two quantitative results, very much like the results of the survey of preference, in addition to the questionnaire results A3, A1 and A4 and the sun hat fractal design yielded the same results. The experimental results of handbags and handkerchiefs are also consistent with the objective quantitative results carried out in this paper, which verifies the effectiveness of the product form design method based on fractal geometry and artificial intelligence for the cultural symbol of the Maonan flower bamboo hat.

**Table 7.** Product form design determination results

| | Fractal design results | Questionnaire design results |
|---|---|---|
| | Sun hat | |
| Very fond of | A1, A4 | A1, A3, A4 |
| Very dislike | | A5 |
| | Handbags | |
| Very fond of | B1, B7, B8 | B7, B8 |
| Very dislike | | B2, B4, B6 |
| | HandkCrBhiCf | |
| Very fond of | C2, C3, C7 | C2, C3, C7 |
| Very dislike | | C5, C8 |

## 5. Conclusion

This paper studies the theory of fractal, proposes the L system and iterative function system and other fractal methods, and applies them to the rattan weaving art innovation design, to broaden the design ideas of rattan weaving art related to the Maonan flower bamboo hats to optimize the inheritance of the cultural symbols of the Maonan flower bamboo hats.

The irregular snowflake pattern is generated by the iteration of affine transformation, which has a certain regularity in the composition, and there are obvious differences in the clarity of the graphics generated by 10,000 and 50,000 times of fractal iterations. The clarity improves with the increase in the number of iterations. The pattern generated through the iteration of the above method can be used as a form of rattan art design morphological innovation.

The morphological elements of sun hats, handbags and handkerchiefs products related to the cultural heritage of Maonan flower bamboo hats were coded, and high preference shapes and low preference shapes were selected for characterization. Comparing the analyzed results of the questionnaire with the quantitative results based on the fractal theory, the results of the survey of very like preference are consistent with the results obtained from the fractal design of A1 and A4 with the sun hat, B7 and B8 with the fractal design of the handbag, and C2, C3, and C7 with the fractal design of the handkerchief. The validity of the product form design method of Maonan flower bamboo hat cultural symbols based on fractal theory and style migration is verified, which can provide scientific reference for future design work.

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