Research Article

Feature Extraction Technology-Guided Visual Communication Design for Folk Paper-Cutting

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Folk paper-cut art is one of the bright pearls, with a wide range of shapes and a long history, that serves as a model for modern visual communication design in China and encourages designers to think creatively. Integrating emotional elements into a design not only can elicit an emotional response from the viewer but also can make works created using traditional rational thinking more vivid, energetic, and touching. The main focus of this research is on the path and method of incorporating folk paper-cut emotion into visual communication design. The research status of various feature extraction methods and image recognition methods at home and abroad is examined in depth in this paper. For the recognition of distorted images that are not transformed by mathematics, some effective methods are proposed. They are used to recognize artistic images of paper-cut patterns because they can extract effective features that are not affected by translation, rotation, scale change, or small deformation. Experiments have shown that they have a positive impact. The use of folk paper-cut art in visual communication design not only improves the quality of design work but also generates new ideas for the transmission and development of other traditional Chinese cultures.

1. Introduction

As one of the traditional folk art forms in China, paper-cutting has been developing for more than 3,000 years. As one of the most distinctive art forms of folk culture, Chinese traditional paper-cut patterns, after historical baptism and deduction, have become an “image” cultural symbol with its unique artistic concept and modeling means and are the visual carriers of Chinese traditional art, culture, and spirit [1]. Chinese modern experimental art and commercial culture design under the multicultural background have made a new interpretation of the “image” of folk paper-cut patterns through different contexts [2, 3].

The use of various forms of artistic expression, such as words, pictures, artistic modeling, and so on, to serve as information transmission and artistic promotion is referred to as visual communication design. The flatness, decoration, and cultural imagery of traditional paper-cut art are interpreted and designed through the visual communication design, which not only can give the visual communication design a strong expressive force but also can inherit and develop the paper-cut art [4–6]. The digital information age necessitates a mode of design thinking that is connected, integrated, systematic, and pluralistic, requiring us to recognize design problems from multiple perspectives and solve them using a holistic approach. Complementary perspectives and methods are one of the design methods that has piqued the author’s interest and warrants further investigation [7]. Combining traditional folk paper-cutting with visual communication design and adding folk art to the foundation of modern design not only enriches the connotation of traditional culture but also adds an endless supply of new ideas to visual communication design.

With the blurring of traditional design boundaries and the visualization of emotional factors in design, the integration of emotion in visual communication design has become the decisive factor for the success or failure of design [8]. This paper combines wavelet analysis with other feature extraction methods. Wavelet analysis has the characteristics of multiresolution. If the features of images can be extracted based on wavelet multiresolution, the representation ability of feature vectors to images will be improved. By extracting
WM from the paper-cut pattern image, the multiscale features of the image can be obtained. The mean and standard deviation of different feature components are used to realize the feature selection of N-type patterns. Experiments show that this method can effectively remove noise interference and better identify paper-cut patterns with certain artistic exaggeration.

In this paper, the features and recognition methods of deformed images with nonstrict mathematical transformation are studied. The extracted features are not only geometrically invariant but also can recognize deformed images to some extent. In theory, the method of image recognition is broadened, and combined with the research of paper-cut art, it is applied to computer paper-cut, which lays a foundation for the realization of computer paper-cut.

2. Related Work

Although there were some new names for visual communication design more than ten years ago, it is now buried in the “visual age” and “visual culture.” Literature [8] puts forward that visual communication design is a planned and effect-oriented design image generation and communication activity for people to achieve a certain purpose (such as information transmission, influence, promotion, and expression), that is, the design of the design image and its transmission mode. Literature [9–11] hold that visual communication design is a process in which designers transform ideas and concepts into visual symbols to convey information by visual symbols. Literature [12] holds that it includes the design of “visual communication design,” graphic design, such as posters, photography, signs, fonts. Literature [13] holds that visual communication design refers to a design activity that uses modeling means and various visual media to convey information, mainly including the design and expression of visual information elements such as graphics, words, colors, images and aims to convey information accurately, quickly, and effectively. The design process mainly includes the generation of plans and ideas, translation and generation of visual images, and presentation and transmission of visual information. Literature [14] introduces the relationship between people and things in design and emphasizes how to grasp the design idea of starting from people’s needs and returning to people when human beings enter the information age of audiovisual new sensibility from the age of reading and writing. Literature [15, 16] focus on the analysis of designers and audiences, discuss the differences between the psychological starting points of designers and audiences, and finally attribute the core concerns of visual design to the practicality of products and the emotional experience of audiences. Literature [17] has a more in-depth exposition on designer psychology, product experience, and experimental design of design psychology. Literature [18] reveals the general creative psychological activity law of art designers themselves in the creative process and guides and meets the psychological needs of consumers through design.

Template matching is the simplest method of image recognition, and it can be divided into two categories: rigid body shape matching and deformed template matching. Template matching is the process of comparing the template to the image to be recognized in order to find areas in the image that are the same or similar. Character recognition, face recognition, hand shape recognition, and other fields all use template recognition. Several finger outlines in the whole hand shape are extracted as templates in the literature [19], and the recognition rate is greatly improved by using the method of block matching and the function of direction angle. The Clifford convolution algorithm of template matching is used in literature [20] to improve the grid division of flow fields for a given flow field. Literature [21] proposes a fast template matching method that identifies the target by combining the central invariant moment with the template, aiming to overcome the drawbacks of large computation, rotation, and scale influence. The sample data from high-dimensional space were projected into one-dimensional space by literature [22] so that different samples were as far apart as possible, while similar samples were as close as possible. Literature [23] improved it by employing weighted or adaptive methods, resulting in a more accurate minimum distance method. Literature [24] investigated the graphic generation method for paper-cut patterns and used computer graphics technology to generate spline curves to construct paper-cut patterns, resulting in the creation of a computer paper-cut system based on patterns and the automation of the paper-cut system. Literature [25] is a breakthrough in the field of paper-cut pattern design, employing a genetic algorithm to generate a variety of paper-cut patterns in various styles.

3. Research Method

3.1. Convey the Emotional Integration of the Basic Elements of Folk Paper-Cutting in Visual Design. Folk paper-cut art, as a special form of artistic expression, has been loved by people in the process of its emergence and development, and working people pin their beautiful feelings on paper-cut. As a unique symbol, paper-cutting also has its unique use-value, conveying the faith of working people. Chinese traditional paper-cut art contains the aesthetic taste and modeling creation of working people. Working people pin their feelings on paper-cutting art and show their interest in life through different paper-cutting art forms. Visual communication design mainly analyzes and summarizes the images in paper-cut art and then displays them in the design works.

Traditional Chinese paper-cut art is primarily red with white accents, with simple red and white colors used to express paper-cut art. Paper-cut artistic modeling primarily expresses people’s emotional experiences by combining reality and reality and incorporating images of everyday animals into paper-cut. Working people’s lives are mostly represented by paper-cut art. They can think creatively and express themselves exaggeratedly through various modeling patterns because they are not overly bound. This is similar to western artistic expression, and the works of art are romantic in nature. Direct graphical emotional expression and indirect graphical emotional expression are the two types of graphical emotional expression. The direct
expression of graphic emotion is a realism built according to the original appearance of objective images, with a shape that is similar to the actual shape, reflecting true details and the typical essence of images. Indirect graphic forms are conceptual symbols created according to the prototype's concept and meaning, making it impossible for people to distinguish the original image and meaning. They are graphic forms with objective meaning derived from pure geometric concepts such as points, lines, planes, bodies, and their combinations or graphic forms with simple characteristics derived from them, and they are widely used in business, such as logo design.

Image motion is one of the most characteristic design factors, and it is also the fundamental difference from the traditional static visual communication design form. The way of movement can be divided into the movement of visual elements (images, characters, colors, lines, etc.) and the movement of design space areas (as shown in Figure 1).

For the movement with visual elements as the main body, it can generally be realized through image change, position change, and nature change. These methods draw lessons from the methods of visual communication design with printing as the carrier, but the difference is that in dynamic activities, more emphasis is placed on the process evolution and dynamic changes, rather than a single result. The visual elements can move in a two-dimensional plane or three-dimensional space.

Because there are so many different ways to express punctuality, different forms will have different emotional expressions. A larger point, for example, will give the impression of conciseness, simplicity, and lack of hierarchy. Small dots will be rich, gleaming, insignificant, and dispersed. There is a sense of detention and order. Dots are athletic, supple, and flawless. People will experience various emotions as a result of various combinations. The sum of point, line, and surface emotions creates modeling emotion. The incomplete shape gives people a sense of regret and sigh; complete shape gives people a sense of complete and complete emotional feeling. Virtual bodies give people a sense of emptiness and floating nothingness, while entities provide a real and credible sense of existence. People with a large shape experience a lot of depression, while those with a small shape experience a tight contraction. Geometry instills a sense of rigor in people, while freedom instills a sense of relaxation. Abstract modeling gives people a sense of science fiction transcendence and psychedelic mystery.

Decorative design is mainly for external image design of decorations, including external image and internal concept communication. Therefore, designers can deform the original patterns by exaggeration and pay attention to the use of paper-cut art concepts to enhance its cultural connotation to arouse consumers’ consumption resonance. Therefore, in the decoration design, learn the exaggerated techniques of traditional paper-cutting art, update the design concept of visual communication, and improve the design level.

![Figure 1: Analysis of motion mode of a dynamic image.](image.png)

### 3.2 Research on Paper-Cut Pattern Recognition

#### 3.2.1. Pattern Recognition Based on R-T and SVD

Paper-cut pattern pretreatment is an important link in pattern recognition and classification. The preprocessing of this paper includes background denoising, image graying, and binarization, as shown in Figure 2.

Compared with other crafts, paper-cutting materials and tools are the simplest, mainly composed of paper, scissors, carving knives, and so on. Because of the tools, paper-cutting has its own characteristics in artistic features. On the basis of its hollowed-out shape, there are two situations, that is, lines are connected or lines are broken. The paper-cutting has a simple and exaggerated aesthetic feeling. Simple modeling, clever and imaginative artistic conception, concise structure, and bright colors have become the important features of paper-cutting art.

The mathematician Radon studied the problem of finding the function along the integral value of a straight line or plane in two- and three-dimensional functions, which is called R-T (R-transformation) of Euler space. Nowadays, it has been widely used and played an important role in image recognition.

The radon transform of an N-dimensional function \( f(x_1, x_2, \ldots, x_n) \) is defined as the integral value on the \( n-1 \)-dimensional hyperplane. When \( N = 2 \), the radon transform of the function \( f(x, y) \in L^2(D) \) on the plane refers to the integral of \( f(x, y) \) along all possible straight lines, which is recorded as follows:

\[
 p(t, \theta) = R(t, \theta)[f(x, y)] = \int_{D} f(x, y) \delta(t - x \cos \theta - y \sin \theta) \, dx \, dy, \tag{1}
\]

where \( \theta \in [0, 2\pi] \), \( \delta \) is the impact function, and \( D \) can be a circle or other plane area.

Let image \( f(x, y) \) be \( p(t, \theta) \) after radon transform, and continuous R-T definition is as follows:

\[
 R(\theta) = \int_{-\infty}^{\infty} p^2(t, \theta) \, dt. \tag{2}
\]
In order to achieve the desired effect, follow the characteristics of WD (wavelength decomposition) to get the details of the pattern, and use the multiscale characteristics of WD to describe the changing characteristics of images on different scales, which is more suitable for image information processing.

Let \( f(x, y) \) represent a continuous function, and the continuous standard moment of the image can be defined as follows:

\[
m_{pq} = \iint x^p y^q f(x, y) dx dy.
\]  

(5)

By transforming the equation from rectangular coordinate system to polar coordinate system, the moment characteristic expression with rotation invariance can be obtained as follows:

\[
F_{pq} = \int f(r, \theta)g_p^q(r)e^{iq\theta} r dr d\theta,
\]  

(6)

where \( g_p^q(r) \) is the radial component of the transformation kernel and \( e^{iq\theta} \) is the angular component of the transformation kernel. Order

\[
S_q(r) = \int f(r, \theta)e^{iq\theta} d\theta.
\]  

(7)

Further change the above formula into

\[
F_{pq} = \int S_q(r)g_p^q(r) dr.
\]  

(8)

If \( g_p^q(r) \) is a function of the local definition of the variable \( r \), the difference between samples may be larger, and the noise will inevitably decrease so that the change areas of sample features are unlikely to overlap with each other, which is a key idea to extract invariant moments of appropriate order from images by using wavelet transform.

Here, the WM (wavelength moment) extracted by the above method is used as the feature vector of the paper-cut pattern. However, due to the high dimension of WM features extracted by different scale factors, selecting favorable features reasonably and effectively and reducing feature dimensions appropriately can eliminate redundancy, speed up operation, and improve classification efficiency.

There are \( \omega \) pattern classes to be distinguished, and each pattern class has one sample. Let the sample be \( s \), where \( i \) is the \( i \)-th sample of pattern \( r \) and \( k \) is the \( k \)-th feature component of sample \( i \); then the mean and standard deviation of the \( k \)th feature component of pattern \( r \) are as follows:

\[
m_k^r = \frac{1}{n} \sum_{k=1}^{n} X_k^r,
\]

(9)

\[
\delta_k = \sqrt{\frac{1}{n} \sum_{k=1}^{n} (X_k^r - m_k^r)^2}.
\]
For two kinds of samples, the larger the gap between the mean values of a certain one-dimensional feature component and the smaller the sum of variance, the better the separability of the component.

If China’s modern visual art is to establish its own cultural identity in the international cultural exchange world, it must research and utilize its own country’s traditional cultural resources while innovating and developing modern visual art and design. The significance of this issue has grown in recent years. As a result, the significance of this paper is to innovate the “image” of traditional folk paper-cut patterns using western theories, to inherit and express Chinese traditional culture in the most appropriate form, and to build Chinese contemporary visual art and design with local cultural connotation.

4. Results Analysis and Discussion

4.1. Experimental Results and Analysis of R-T and SVD Recognition. The artistic conception beauty of design works is the highest level of spiritual function and the highest requirement for visual design, which means that the environment has a specific atmosphere or profound artistic conception. The space mentioned here also has two meanings. The first one is the real space, that is, the real three-dimensional design and expression space. The second is the picture space, that is, the space of false two-dimensional plane design and expression. The visual communication design is more focused on the latter’s space design.

The use of corresponding association to change unfamiliar to familiar, and to change the cognition, understanding, feeling, and experience of the other object to the theme to be expressed, is primarily used in the theme expression of visual communication design. The audience is more familiar with the other object than the theme to be expressed, making it easier for them to understand and accept it. People’s imagination and creation can be used to enhance the theme’s connotation. As a result, it is not advisable for China’s modern visual art design to deliberately pursue national traditions in order to compensate for deficiencies or to westernize in order to accommodate international styles. Instead of sticking to certain appearances and styles, one of the best development directions is to learn from the expression of “image” in folk paper-cut patterns and create contemporary visual art with national cultural connotations.

R-T experiments are carried out on images with different geometric transformations of the same pattern, and the results are shown in Figure 3.

From this, the nature of R-T translation, scaling invariance, and rotation cycle motion can be seen clearly. Because the singular value of the matrix is independent of the position of rows and columns, the rotation variation can be eliminated according to this characteristic.

Design emotion and design thinking are the basic elements that any art category should possess. Emotion without proper thinking cannot constitute design, and thinking that cannot express emotion cannot be regarded as art either. In order to make visual design works have a profound artistic conception, from the creative point of view, it is necessary to see the situation and express feelings first and then express feelings, that is, entrust things to express feelings. From the perspective of appreciation, it means that the欣赏者 can be inspired, felt, edified, and even shocked by inspiration from the perceived spatial environment, which can arouse the resonance of thoughts and emotions, that is, feel the situation and feel the emotion suddenly.

The experimental results of noise resistance comparison between the two methods are shown in Figure 4. It can be seen that this algorithm is more robust than radon invariants and can well overcome the influence of noise.

The following shows that the algorithm in this paper is more effective in translation, rotation, scale invariance, and similar image recognition than the algorithm in reference [24]. The experimental results are shown in Figure 5.

The features obtained by using R-T and SVD are invariant, as shown in Figure 5, and the algorithm is simpler and more effective than radon moment invariants. R-T has a minor effect on the scale here, which is primarily due to some jaggies in the enlarged image. Visual communication design is based on artistic ideas and modeling characteristics, deconstructs folk paper-cut art expression skills again, and perfectly combines folk paper-cut with visual communication design, enriching the category of visual communication design. Visual communication design has evolved into a new form of personalized and traditional artistic expression in recent years.

The second group of experiments is feature extraction of similar images. Here, only some illustrations are listed to illustrate their singular value features, as shown in Figure 6.

It can be seen from Figure 6 that the invariant features constructed by radon are scattered, and the features in the same category differ greatly, so the method in reference [24] is not suitable for feature extraction of deformed images. The method of R-T and SVD is better.

Modern visual communication design is the reconstruction of graphics and images, and it is based on universal visual language to create a lot. Instead of sticking to the expression of objective images, the expression of ideas is usually carried out with the help of designers’ subjective thinking mode, which will come from everyday life and all kinds of things.

In this paper, a large number of experiments have been carried out on seven kinds of patterns, which proves that this method can effectively extract invariant features. Due to the limitation of space, only four samples are listed for each of the following patterns, as shown in Figure 7.

From Figure 7, it can be seen that the characteristics of these seven modes are different, but they are relatively concentrated on the whole. In recognition training, those patterns that are too scattered can be removed, which is conducive to correct pattern classification. For patterns with complex deformation, there will be some cross-feature values.

Visual communication design should not only highly summarize the folk paper-cut art but also highly purify these artistic shapes, so as to find a concise and clear modeling image to embody in the visual communication design, thus
enhancing the artistic appeal. With the continuous development of science and technology, the performance field of visual communication design has also brought new changes, with more emphasis on the integration of traditional and modern elements.

4.2. Analysis of Pattern Recognition Results Based on WM. Visual communication design is not only the fullest beautification and decoration of artistic image but also the ideological expression of artistic creators. For example, the auspicious symbols in folk paper-cut art are applied to visual communication design, which shows the lofty idea of the happy life of the folk people and unique artistic skills. Visual communication design conveys realistic art and different kinds of artworks all present the public’s thinking mode and aesthetic concept.

Sort each column from largest to smallest and set the threshold value to the average of the first three feature components. As the final feature vector, choose the feature component with a resolution greater than the threshold value. Despite the high resolution of some feature components, their feature values are small and have little impact on the Euclidean distance classifier. As a result, such feature vectors can be directly discarded to reduce redundancy and improve calculation speed. The identification result of WM is shown in Figure 8.

According to the above Figure 8, it can be seen that the WM method has a good recognition effect for different types of patterns. The high recognition rate of WM is mainly attributed to WM’s grasp of details. The WM features extracted after image normalization are invariant to translation, scaling, and rotation of moment features. At the same time, the multiscale characteristics of WM features make WM invariants represent not only global features of images but also local features, so they can better represent the differences in image details and have a higher recognition rate when identifying similar objects.

The feature extraction method proposed in this paper is based on WD. Here, the feature extraction proposed in this paper is compared with other recognition methods, as shown in Figure 9.

According to Figure 9, it can be seen that among the above four feature extraction methods based on wavelet transform, WM has the highest recognition rate, mainly due to the multiscale characteristics of WM features, which makes WM invariants not only represent global features of images but also represent local features. However, its feature extraction process is cumbersome, and at the same time, it is complicated to select the extracted features.

The forms of folk paper-cutting collide with new energy and new technology in the development of modern design, absorbing the cultural characteristics of various styles and resulting in certain creations. It is reexhibited in a brand-new form through various expressions of visual communication design, resulting in folk art that not only meets the needs of the times but also retains its own distinctive characteristics. The paper-cut image is a very real modeling language with more prominent morphological features in traditional visual elements. Artists combine the ever-changing artistic images of folk paper-cutting with contemporary modeling languages and artistic forms to provide people with endless emotional experiences and a happy atmosphere. Each of us has a deep understanding of these symbolic languages and ideologies. After historical changes, people continue to love and recognize them, and they have become a popular artistic pursuit in the public’s minds.

People process the inherent attributes of things, and with the symbolic connotation of art, folk paper-cutting uses a lot of decorative techniques of symbols, metaphors, and semiotics to convey emotions and conveys happy wishes. Modern designers use this expression to exert great creativity and imagination, expand the inherent space of design,
**Figure 5:** Comparative experiment of geometric transformation.

**Figure 6:** Contrast experiment of deformed patterns.

**Figure 7:** Pattern characteristics.
create more valuable artistic works, and form the inherent artistic language of folk local design.

5. Conclusion

Chinese traditional paper-cut art modeling has become increasingly popular as modern society has progressed. In the design process of artworks, people always incorporate patterns in paper-cut art. Paper-cut art can provide materials for designers to innovate when incorporated into modern visual communication works. These works of art can pique people’s interests and help them communicate their charm more effectively. It is the key link between Chinese culture and world art, and the folk forms it contains are exactly what modern visual communication seeks. Today, with the rapid advancement of science and technology, the folk paper-cut art will be presented to the world with a brand-new creative technique, and the entire aesthetic form will be developed and can be extended and inherited for a long time, in order to preserve the folk art more completely. This paper also focuses on the method of feature extraction. The structural features of the target are represented by the features extracted in this paper, which are not affected by translation, rotation, or scale transformations and have good robustness. Experiments have shown that these techniques are effective.

The next step will be to develop a paper-cutting-friendly image segmentation algorithm. Image segmentation will divide and identify a complete paper-cut image into individual patterns in several pattern libraries, allowing complex patterns to be recognized.
Data Availability
The data used to support the findings of this study are included within the article.

Conflicts of Interest
The author declares that there are no conflicts of interest.

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