

Extraction and Reuse of Visual Elements of Tourism Cultural and Creative Products Based on Deep Learning

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Abstract. With the development of urbanization, people's demand for products continues to extend outward, and the demand for tourism CCP (Cultural and Creative Products) is also increasing. As an important part of traditional culture, traditional handicraft can make products with special artistic value and charm by hand. If the paper-cut patterns can be classified by computer instead of manual, the automation of computer pattern generation can be greatly improved. This paper studies the extraction and re-application of tourism CCP visual elements based on deep learning. The extraction model of visual elements of arbitrary shape paper-cut patterns proposed in this paper consists of two parts: encoding and decoding. The feature sequence is obtained through CNN (Convolutional Neural Network), and then the feature sequence is sent to the bidirectional GRU (gated-current unit) network to extract image features; The decoding part first allocates the structural attributes of the image feature sequence through the attention model, and then outputs the recognized paper-cut patterns through the GRU network. The results show that the geometric features of different types of patterns are quite different, and these features can better distinguish different types of patterns. In the recognition network, the establishment of graph attention model can further improve the recognition accuracy; In the field of paper-cut pattern extraction, compared with the latest methods, this method is competitive enough.

Keywords: Deep learning; Cultural and creative products; Visual elements; Paper cutting pattern

1. Introduction

CCP (Cultural and Creative Products) is the combination of creativity and characteristic resources, which is conducive to the spread and promotion of cultural characteristics, and enhances its corresponding popularity and influence. At present, regional cultural elements are more or less used in CCP design of many scenic spots, for example, printing famous scenic spots on related tourist souvenirs and labeling some CCPs with regional cultural labels. However, it is not practical to copy regional cultural elements directly to tourism CCPs [1-2]. With the rapid development of mechanical technology, the traditional handicrafts have been replaced by machinery, and the situation of traditional handicrafts has become very difficult. As an intangible cultural heritage, its future development is facing unprecedented challenges.

With the development of urbanization, people's demand for products continues to expand, and the demand for tourism CCP is also increasing. This requires that the design of tourism CCP not only need to have the basic service function of tourism, but also need to provide a higher level of aesthetic function and service function for human beings, so as to reflect the regional cultural value. Under this premise, paper-cutting art has also ushered in a broad development space and prospects. Compared with traditional paper-cutting art, modern paper-cutting art has more cultural connotations and innovations [3-4]. After decades of development, more achievements have been made in image recognition. The template proposed by Xu Weihe et al. is no longer fixed, but a fast deformation template combined with genetic algorithm, which can accurately calculate the angle between the chip and the horizontal line and the relative position of the chip solder joint [5]. Xue Wen et al. put forward a digital recognition method based on RBF network by taking RBF network as the recognition model and adopting competitive algorithm. The simulation results show that this method has the advantages of high recognition rate and fast recognition speed, and has a broad application and popularization value [6]. Xing Lu et al. studied the graphic generation method of paper-cut patterns, and used computer graphics related technologies to generate spline curves to construct paper-cut patterns, and thus designed a computer paper-cut system based on patterns, which realized the automation of paper-cut system [7].

As an important part of traditional culture, traditional handicraft can make products with special artistic value and charm by hand. It is very necessary to strengthen tourist attractions and cultural propaganda in the region, so as to further enhance the popularity and attract more tourists [8]. CCP itself is a creative product of regional culture, with certain cultural characteristics and contents. The traditional CCP is relatively single in design and subject matter. If the paper-cut patterns can be classified by computer instead of manual, the automation of computer pattern generation can be greatly improved. In terms of technical realization, it combines the traditional paper-cutting art of China with image processing technology, thus opening up a brand-new art design form with innovative significance.

2. Research method

2.1 Paper-cut pattern pretreatment

Paper-cut art, as a unique handicraft art in China, is deeply loved by the public for its shape and cultural connotation. As a designer, we should take root in the masses and create modern products with traditional cultural connotations that the masses expect. In terms of theme selection and moral expression, paper-cutting art shows the culture, customs and spiritual yearning generally recognized by the public, and occasionally shows the artist's personal subjective interest and aesthetic will. On the whole, the art of paper-cutting has something in common in creation theme, moral expression, expression technique and color. Like other art forms, it is permeated with China's classical philosophy and connotation.

Pretreatment of paper-cut patterns is an important link in pattern recognition and classification. In the process of collecting paper-cut images, due to the problems of books and instruments, it is polluted by different degrees of noise, which makes the images not clear enough and makes the subsequent processing difficult. The preprocessing of this paper includes background denoising, image graying and binarization, as shown in Figure 1.

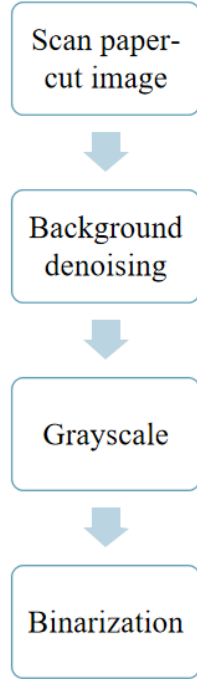


Figure 1. Pretreatment process

Feature vectors play an important role in image recognition, so it is necessary to characterize the essential features of this kind of image when determining the feature vectors. As the feature of moment pattern, it is widely used in two-dimensional image pattern recognition. At present, moment features have been widely used in many aspects, such as target recognition, scene matching, shape analysis, image analysis and paper-cut pattern recognition.

Because the patterns in artistic works are exaggerated and distorted, the patterns of different paper-cuts are quite different [9]. Moment invariants, with clear concept and stable recognition rate, have good invariance and anti-interference to objects with rotation and scaling changes, and can effectively reflect the essential characteristics of images.

Let the gray function of a two-dimensional discrete image of $m \times n$ be represented by $f(x, y)$, and its order $p + q$ moment is defined as:

$$m_{pq} = \sum_{x=1}^m \sum_{y=1}^n x^p y^q f(x, y) \quad (1)$$

Two first-order moments (m_{10}, m_{01}) represent the gray center of gravity of the image. When the camera and the target move in parallel to the image plane, the center of gravity changes accordingly.

The collected images may be disturbed by noise for various reasons, which leads to the decrease of image signal-to-noise ratio, which directly leads to some details of the images being submerged in noise, which not only affects the image quality, but also affects the subsequent processing. In order to carry out high-level image analysis and understanding, it is necessary to minimize the influence of noise.

The frequency domain method transforms the image, and then selects an appropriate frequency domain filter for filtering, including frequency domain low-pass filtering, wavelet transform denoising, ridgelet transform denoising and so on.

Neighborhood averaging is a simple spatial smoothing technique, which belongs to linear filtering [10]. There is an original image $f(x, y)$ of $N \times N$, and the image processed by the neighborhood average method is $g(x, y)$, then:

$$g(x, y) = \frac{1}{M} \sum_{(m,n) \in S} f(m, n) \quad (2)$$

Where S is the neighborhood centered on (x, y) , and M is the total number of coordinate points in the set S .

Scene graph is a method of arranging data into hierarchical structure, and scene graph generation is based on scene graph for multi-modal input data such as audio, video, images and paper-cut patterns, and automatically converts unstructured semantic information in the input data into structured triple information. For paper-cut pattern matching and recognition, color is secondary, other information is needed, and the speed of binary image operation is fast, so the pattern image is binarized [11].

The binarization of an image means that by setting the threshold T , the gray value of pixels greater than or equal to T in the image is assigned to 1, and the gray value of pixels less than T is assigned to 0, so as to obtain a black-and-white image with only two gray values of 0 and 1. The binarization conversion rules of gray scale images are as follows:

$$g(x, y) = \begin{cases} 1, & f(x, y) \geq T \\ 0, & f(x, y) < T \end{cases} \quad (3)$$

$f(x, y)$ is the value of the original pixel, $g(x, y)$ is the value of the binarized pixel, and T is the threshold.

2.2 Extraction of visual elements

In recent years, with the development and integration of computer-aided design technology, China's paper-cut creation has been greatly promoted in diversification and innovation. Zhang Xianquan, etc. realized the generation of paper-cut images by establishing a paper-cut pattern system [12], and decomposed it to obtain that the structure of paper-cut images is mainly composed of two types of patterns: the main outline pattern and the interior decorative pattern.

The works of paper-cutting are very rich, mainly because the pattern changes produce different artistic effects. The most important thing is that the paper-cut pattern image is different from other pictures. Two similar patterns don't necessarily have strict mathematical transformation. They are the result of artistic exaggeration and deformation, and they are random, so it is not ideal to use general invariants to identify them.

Graphic information is stored in the computer by converting it into digital information. After being converted into digital information, users can operate the computer to operate the image after digital informatization [1]. Nowadays, the digital image processing technology is not what it used to be. The diversity of image processing is strong, the accuracy of image processing is high, and the reproducibility of image processing algorithm is excellent. Digital image processing technology can be used for fingerprint recognition, handwriting recognition and unclear image recognition and processing. The importance of image processing has been constantly presented to the world, so a worldwide upsurge is emerging. Many talents and materials have been invested in the development and research of image processing in every corner of the world, and China's investment and achievements in this direction are also very huge.

Deep learning is an important research field in machine learning. Different from traditional machine learning, deep learning uses a neural network structure with more hierarchical structures, more nodes and more complex connections, which is used to learn more effective features from massive data, so as to process more complex and higher-dimensional data so that the established algorithm model can learn "experience" and draw inferences from others. Different from traditional artificial feature extraction methods, such as scale-invariant feature transformation, local binary method and histogram method, image feature extraction technology based on deep learning can automatically and massively collect abstract features and deeper semantics of input images.

The extraction model of visual elements of arbitrary shape paper-cut patterns proposed in this paper consists of two parts: encoding and decoding. The input of the encoding part is the corrected image, that is, the feature sequence is obtained by CNN, and then the feature sequence is sent to the bidirectional GRU (gated recurrent unit) network to extract image features. In the decoding part, the structural attributes of the image feature sequence are assigned by attention model, and then the recognized paper-cut patterns are output by GRU network. The extraction model structure of tourism CCP visual elements is shown in Figure 2.

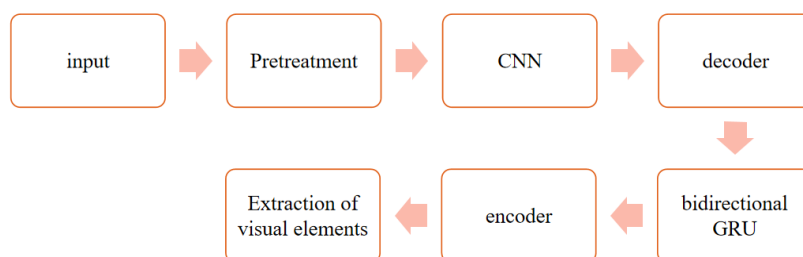


Figure 2. Extraction structure of tourism CCP visual elements

The essence of wavelet transform of an image is to decompose a two-dimensional signal on different scales, so that sub-bands with different frequencies can be obtained, and the energy can be calculated according to the components on each scale.

In this paper, the commonly used db^2 wavelet is used to decompose the pattern image after Fourier-Mellin transform into two layers. There are many definitions for calculating the energy at each layer scale. Generally, the average energy operator is used:

$$E_i = \frac{\sum_{x,y} c_i(x,y)^2}{M \times N} \quad (4)$$

$c_i(x,y)$ is the wavelet coefficient on each scale, and M, N is the size of each layer subband.

CNN's training model requires pre-training. When the amount of data is small, you can only update the parameters of the last layer of the network. When the amount of data is medium, you can retrain the parameters of the later layers. When the amount of data is large, you need to start training from scratch.

Activation function is an indispensable part of constructing neural networks. Activation function is a method to make up for the lack of expression ability of linear models. Its appearance solves a problem that is nonlinear factors in neural networks. In this paper, the activation function ReLU is selected:

$$f(x) = \begin{cases} 0, & x < 0 \\ x, & x \geq 0 \end{cases} \quad (5)$$

Its advantage is that it can converge quickly, effectively alleviate the problem of gradient disappearance, and it can perform well without unsupervised pre-training, thus providing the sparse expression ability of neural network.

After the integration of texture features and structural features, the overall probability of the integrated features of each paper-cut pattern image will be evaluated. Under the action of Attention mechanism, the connection sequence of paper-cut patterns will become the focus, and the coding c_i is not a separate input, but a weighted sum of the characteristics of each paper-cut pattern according to the importance. The weighted coding can be expressed as:

$$c_i = \sum_{j=0}^{T_x} a_{ij} f(x_j) \quad (6)$$

i represents the time, j represents the j th characteristic element, T_x represents the characteristic length of paper-cut patterns, and $f(\cdot)$ represents the coding of element x_j . a_{ij} is the probability value, indicating the importance of element x_j to c_i , which can be expressed as:

$$a_{ij} = \frac{\exp(e_{ij})}{\sum_{k=1}^{T_x} \exp(e_{ik})} \quad (7)$$

e_{ij} represents the matching degree between the feature to be coded and other features, and the matching degree is the similarity ratio between the weighted sum of feature importance and the feature importance in the training set. The higher the matching degree, the greater the a_{ij} value.

3. Applied analysis

In the experiment, 10 basic images of each pattern are selected as training samples of CNN, and there are 55 images of 6 patterns, which basically cover common patterns in paper-cutting creation. By binarizing it, the subsequent calculation can be simplified and the operation efficiency can be improved. The size of the preprocessed binary image is 108×108 . By calculating the seven invariant moments of these patterns, the feature vectors of this kind of patterns are obtained, which are input as training samples of CNN. After the training, the neural network can be used to classify the patterns.

For the specific paper-cut patterns, the shapes are complex and change greatly, and they have their own unique properties. Different types of patterns have great differences in appearance, and the same type of patterns have similar shapes but great changes. The geometric features are clear, and the differences of these geometric shapes can distinguish different patterns to a great extent, and the extraction of geometric features is simple for strict mathematical shape transformation, and the amount of calculation is small.

In this paper, feature vectors are obtained according to some shape features. The feature quantity results of six geometric features in this paper are shown in Figure 3.

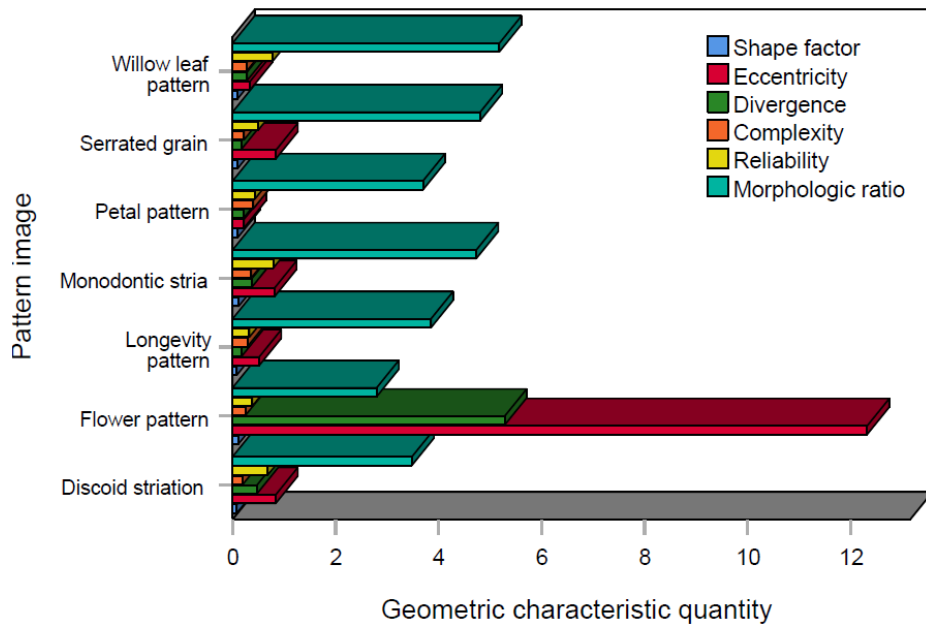


Figure 3. Six geometric features of seven different types of pattern images

It is found that the geometric features of different types of patterns are quite different, and these features can better distinguish different types of patterns. It can also be seen that each geometric feature has limitations. The difference between the eccentricity of willow leaf pattern and petal pattern is small, the difference between the expansion of zigzag pattern and disc length pattern is small, and the difference between the complexity of single tooth pattern and longevity pattern is small. However, the combination of them can achieve good results in shape recognition and matching.

The following shows that our algorithm is more effective in translation, rotation, scale invariance and similar image recognition than that of ref [10]. Their singular value characteristics are shown in Table 1 and Figure 4.

Table 1. Contrast experiment of deformed patterns

Pattern image	our	Ref [10]
Monodontic stria	8.4525	4.5414
Petal pattern	7.9288	3.7332
Serrated grain	6.6338	3.2058
Willow leaf pattern	8.5939	4.4128
Discoid striation	7.0334	5.9215
Longevity pattern	7.1535	6.092
Flower pattern	6.9487	6.1531

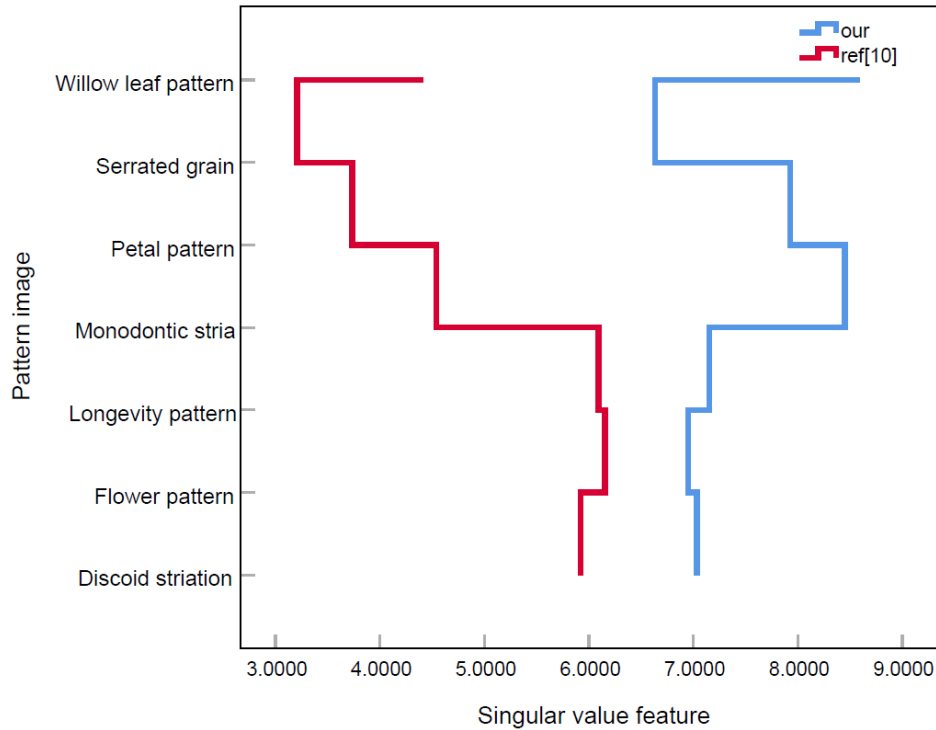


Figure 4. Contrast experimental diagram of deformation patterns

The invariant features constructed by the extraction model of visual elements of arbitrary shape paper-cut patterns are scattered, and the features in the same category differ greatly. The method of ref [10] is not suitable for feature extraction of deformed images. The method of transformation and singular value decomposition is better. In the recognition network, the establishment of graph attention model can further improve the recognition accuracy. In the field of paper-cut pattern extraction, compared with the latest methods, this method is competitive enough, and CNN has more valuable exploration space.

4. Conclusion

CCP is the combination of creativity and characteristic resources, which is conducive to the spread and promotion of cultural characteristics and enhances its corresponding popularity and influence. It is very necessary to strengthen tourist attractions and cultural propaganda in the region, so as to further enhance the popularity and attract more tourists. This paper studies the extraction and re-application of tourism CCP visual elements based on deep learning. Pre-treatment of paper-cut patterns is an important link in pattern recognition and classification. The preprocessing of this paper includes background denoising, image graying and binarization, and the recognized paper-cut patterns are output through GRU network. It is found that the geometric features of different types of patterns are quite different, and these features can better distinguish different types of patterns. In the recognition network, the establishment of

graph attention model can further improve the recognition accuracy; In the field of paper-cut pattern extraction, compared with the latest methods, this method is competitive enough, and CNN has more valuable exploration space.

References

- [1] Qian Baiying. (2020). Application of artistic elements of visual communication in cultural and creative design of agricultural products-comment on Cultural and Creative Design. *China Grease*, 45(12), 1.
- [2] Ni Taile, Feng Zhao, & Chen Yingshuang. (2021). Extraction and deduction of Li Bing's graphic elements based on Pierce's semiotics. *Packaging Engineering*, 42(4), 7.
- [3] Qing Xiaochang. (2020). Qianwei's Visual and Creative Product Design in Tea Thoughts-"Chaotian Beast". *Fujian Tea*, 42(5), 2.
- [4] Xiao You, & Wang Hongliang. (2020). Research on the Application of Local Cultural Elements in the Design of Tourism Creative Products. *Packaging Engineering*, 41(20), 6.
- [5] Xu Weihe, & Zhou Yuan. (2021). Wenchuang Brand Works-Elements. *Shanghai Textile Science and Technology* (2), 96-96.
- [6] Xue Wen, Hu Yunzhong Ze, Tang Lin, Zhan Yuting, Zhu Chengyan, & Zhang Hongxia. (2020). Research on Guizhou folk paper-cut patterns and its innovative design on fabrics. *Silk*, 57(7), 6.
- [7] Xing Lu, & Tang Di. (2017). Synthetic method of paper-cut on Peking Opera face. *Computer Engineering*, 43(12), 5.
- [8] Wen Ying,&Li Hao. (2018). Network recognition of echo state of paper-cut patterns based on fm-mrw features. *Control Engineering*, 25(6), 7.
- [9] Xu Yajuan. (2021). Analysis of Yugur paper-cut patterns and cultural connotations. *Fine Arts*, 2021(7), 2.
- [10] Mujeeb, A., Dai, W. , Erdt, M. , & Sourin, A. (2019). One class based feature learning approach for defect detection using deep autoencoders. *Advanced engineering informatics*, 42(10), 1-9.
- [11] Liu, H. , Luo, S. , Lu, J. , & Dong, J. (2019). Method for fused phase and pca direction based on a sift framework for multi-modal image matching. *IEEE Access*, 2019(99), 1-1.
- [12] Wei, X. , Yang, Z. , Liu, Y. , Wei, D. , Jia, L. , & Li, Y. (2019). Railway track fastener defect detection based on image processing and deep learning techniques: a comparative study. *Engineering Applications of Artificial Intelligence*, 80(8.), 66-81.