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Retraction

Retracted: Paper-Cutting Pattern Design Based on Image Restoration Technology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] J. Yu, "Paper-Cutting Pattern Design Based on Image Restoration Technology," *Security and Communication Networks*, vol. 2022, Article ID 3132047, 9 pages, 2022.

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Research Article

Paper-Cutting Pattern Design Based on Image Restoration Technology

Jianjun Yu

Department of Art and Design, Taiyuan University, Taiyuan, Shanxi 030032, China

Correspondence should be addressed to Jianjun Yu; yujianjun@tyu.edu.cn

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Paper-cutting is one of the valuable intangible cultural heritages of China, with distinctive features such as "round as the autumn moon, sharp as the wheat mane, square as the green brick, missing as the serrated teeth, and thread as the beard," and is a widely spread folk art. The art of paper-cutting brings new inspiration to the design of structures, and by changing the topology of the raw material, the material/structure can undergo significant changes in physical properties, such as optical, thermal, acoustic, and mechanical aspects. The protection of intangible cultural heritage is a process of cultural self-awareness and a kind of cultural reflection and enlightenment. In the history of promoting socialist cultural development, the protection of "intangible heritage" paper-cutting is undoubtedly of great significance. The purpose of digital image repair is to restore the integrity of the broken image, and the process is to fill in the specified area of the digital image with information, requiring a natural transition between the filled area and the original area of the image and minimizing artificial traces, so that the image looks as if it has never been broken. In this paper, the paper-cutting pattern design method based on image restoration technology is investigated, starting from the preprocessing of paper-cutting images by acquiring the edges of the images and using the Criminisi image restoration algorithm with image broken edge reconstruction to realize the image broken edge reconstruction design of paper-cutting graphics. Therefore, the paper-cut graphics generated by the method in this paper are concise and coherent as a whole, which reduces the difficulty of paper-cut design while satisfying individual design requirements.

1. Introduction

In the long history of China, due to the different social divisions of labor, ordinary working people have gradually created the art form of paper-cutting using scissors in their hands [1]. The patterns prepared with the help of scissors or carving knives can give a visually pleasing impression of translucency [2]. As a kind of intangible cultural heritage fully reflecting the history of regional culture and traditional changes, paper-cutting art has cultural value, aesthetic value, economic value, and scientific and educational value, with different levels of roles and embodiments [3]. However, the international design style gives rise to the psychological pressure of monotony, tedium, indifference, and lack of human feelings [4]. Along with the development of China's economy and the growing maturity of domestic visual art design consciousness, visual art design has shifted from an elite modernist culture to a pluralistic development with the masses as the main focus [5]. However, the traditional method of designing various styles of paper-cutting patterns requires first analyzing the characteristics of the patterns and then designing specific algorithms for each pattern; not only is the workload large, but it also requires the operator to have a certain base of artistic creation to achieve [6].

In recent years, some nonrealistic drawing techniques to simulate traditional art media, such as watercolors and pencil drawings, have achieved good results, which has implications for the computer simulation of paper-cutting art [6]. The overall stiffness of the structure is reduced due to the cutout, which gives the structure better flexibility and malleable characteristics [7]. At present, the most representative image restoration techniques at home and abroad are mainly two types of partial differential equation-based restoration models and texture synthesis-based restoration

models [8]. Based on the correlation of known pixels around the area to be restored, the area to be restored is gradually filled to achieve restoration in the human eye effect according to a certain algorithm [9]. Paper-cutting gives an exaggerated, translucent, and abstract feeling visually, exaggerating the physical objects in life and reflecting their interesting characteristics, which originates from life but is higher than life and gives people the enjoyment of art [10].

As one of the most characteristic art forms of folk culture, traditional Chinese paper-cutting has become a kind of "imaginative" cultural symbol with its own unique artistic and aesthetic concepts and modeling methods through history and interpretation [11]. Paper-cutting is presented to the world as a visual carrier of traditional Chinese art, culture, and spirit [12]. The thresholding method is sensitive to algorithm parameters and easily loses details in the image, while the template-based method generates better results but relies on a large library of paper-cut templates, so it is computationally intensive and difficult to maintain the object features in the original image [13]. Therefore, the design of paper-cut patterns using image restoration techniques is also undoubtedly a way to convey traditional folk culture. It can make more people understand the art of paper-cutting and can also lead to the development of the regional economy, allowing the combination of modern and traditional to keep the design up to date [14].

The innovative points of this paper are as follows:

(1) In this paper, a broken edge reconstruction method is utilized for repairing broken images with missing important structures, where the human eye can still perceive a break at the repaired edge that is not smooth enough.

(2) This paper achieves pixel point repair according to anisotropic repair order by continuously maintaining and updating the priority of boundary pixel points throughout the repair process

(3) The article investigates the relationship between hand-made paper-cutting works and pattern design by using image restoration technology from the industry's point of view and takes the design, recognition, and matching of paper-cutting images as the research object, which is a relatively novel perspective.

2. Related Work

2.1. Paper-Cutting Pattern Design. Paper-cutting is a Chinese folk art with a long history of using common tools, simple production, and a wide variety of materials and styles. There are static window decorations and realistic shadows that can be manually controlled for dynamic performance. As a traditional Chinese cultural resource, Chinese folk art of paper-cutting, the "imagery" expression of its patterns coincides with the implications of graphics in graphic design.

Shi et al. decomposed the basic compositional patterns of images based on paper-cut patterns as the object of study, divided these patterns into independent patterns and conforming patterns, and generated new patterns by performing simple logical operations on these basic images, etc. [15]. Liang proposed a design of a computerized paper-cutting system based on a pattern library that contains patterns with many different characteristics and can be adapted to different requirements by parameter transformation in the Journal of Computer Engineering [16]. Duan and Wang analyzed the basic characteristics and structure of paper-cut patterns, classified paper-cut patterns, and studied the methods of pattern generation by using hand-cut paper as the object [17]. Xu et al. conducted an in-depth study on decorative patterns and proposed some composite pattern generation methods, such as expanded symmetrical pattern design and gradient path decoration [18]. Sayed et al. studied and analyzed paper-cutting modeling, extracted paper-cutting images out of the required basic patterns, applied genetic algorithms to pattern generation, and let the computer generate patterns automatically so that the resulting patterns are more colorful, and on this basis, also added the measures of curve uniformity and smoothness to optimize the quality of paper-cutting pattern generation [19].

Traditional Chinese folk paper-cutting patterns are created by working people to meet the needs of their own spiritual life, expressing the passionate and simple emotions of ordinary people. The choice of the pattern for the content is often based on the aesthetic ideal of praying for a better life and the pursuit of beauty to be expressed, consistent with the visual communication of the graphic. After thousands of years of inheritance and development, it has been influenced by many aspects of society and has been integrated and permeated by each other. It is not only a hand-made paper-cutting art but also contains the Chinese economy, politics, culture, life, folklore, spirituality, religious beliefs, and other nonmaterial civilization, and has become an important reference material for the study of history and culture.

2.2. Image Restoration Technology. The use of exaggerated deformation in the patterns of paper-cutting artworks makes the difference between different works of the same type of pattern, and a single characteristic parameter does not describe well the characteristics of different patterns. Nowadays, with the advent of computers, digital cameras, scanners, and other equipment, paper-cutting works are preserved in digital form, and paper-cutting has crossed over into a new field.

Yamanaka and Miyashita decomposed paper-cutting patterns by hand, created a pattern library, and selected patterns in the pattern library to be embedded in specified positions within the paper-cutting contours. The structural information specifically refers to the overall change of the image, outlining the basic outline of the image, which can be considered as a description of a larger scale [20]. The methods proposed by Yang all first segmented the image based on color or structural features and then patched the various regions into which the segmentation was made. Correspondingly, texture information represents local information details, which are generally reflected as recurring specific patterns, such as patterns [21]. Iyer accelerated the development of digitization techniques for the traditional art

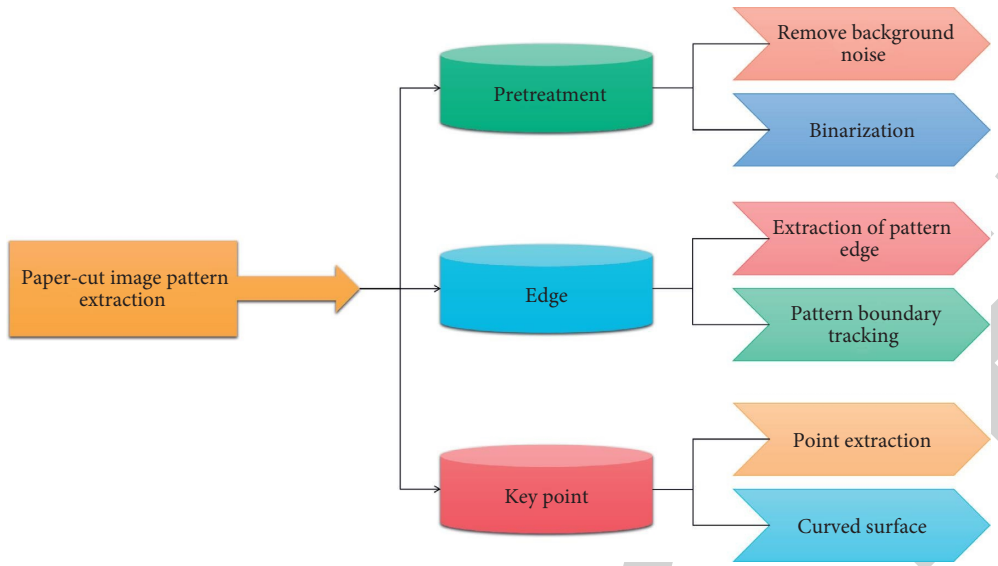

Figure 1: Pattern extraction of paper-cut image.

of paper-cutting by studying a large number of paper-cutting patterns and establishing a database of elemental symbols [22]. Chu et al. proposed an image restoration method that can repair images with overlapping structural textures and other textures, while Higashi and Kanai proposed an adaptive restoration algorithm based on CDD to address the problems of large time overhead and parameter instability in the CDD model, which model dynamically and freely restores the image based on the local feature information of the missing boundary part of the image [23]. The algorithm model dynamically and freely selects the diffusion restoration based on the local feature information of the missing boundary part of the image [24].

In practical applications, whether it is normal life or the application of high-tech occasions, the requirement for images is to provide effective information, so we need to fill in the repair of images with missing information. Based on the existing research results, the article analyzes the characteristics of hand-made paper-cutting art in depth and proposes a paper-cutting pattern design method with image repair technology to improve the above method.

3. Design Ideas of Paper-Cut Patterns Based on Image Restoration Technology

3.1. Paper-Cut Image Preprocessing. Patterns are used for decoration and the process by which they are created derives from the direct design intent of the designer, and many of them are actually the visualized product of imagery [25]. In order to preserve the integrity of flawed artistic treasures, such a group of professionals engaged in art restoration has emerged. For a realistic hand-cut artwork to become a digital image that can be stored, recognized, and processed by a computer, it is necessary to capture and store the graphic image on the computer. Data acquisition is the conversion of objects present in space into digital signals that can be stored and processed by a computer through the use of certain sensors [26]. The paper-cut image pattern extraction module is divided into three submodules: preprocessing, edge, and key point, as shown in Figure 1.

First of all, from the content of the paper-cut image, it mainly consists of the image area and background area. The interference of noise will appear in some bright spots and dark spots, which can be removed by simple mean filtering that does not affect the binarization effect of the image. The input image is lazily segmented to extract the foreground, and then the foreground is blurred to remove the high-frequency part. The image with noise removed is transferred to the computer by the image acquisition card, and the image is processed by the processes of preprocessing, character segmentation, character training, and character recognition to get the segmentation result. The segmentation can be expressed by the following equation:

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

T is the effect of image segmentation

Since there is no algorithm that can directly perform edge detection on color images, it is necessary to convert color images to grayscale images in advance before performing edge detection, i.e., grayscale conversion. Assume the image size is $M \times N$, and use $I_0(x,y)$ and $I_1(x,y)$ to denote the image before and after restoration, respectively, and (x,y) to denote the pixel coordinates. The mathematical expression of the mean square error MSE is as follows:

$$\text{MSE} = \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} [I_0(x,y) - I_1(x,y)]}{M \times N}. \quad (2)$$

The mathematical expression of SNR is as follows:

$$\text{SNR} = 10 \times \lg \left[\frac{\sum_{x=1}^{M} \sum_{y=1}^{N} I_0(x,y)^2}{\sum_{x=1}^{M} \sum_{y=1}^{N} [I_0(x,y) - I_1(x,y)]^2} \right]. \quad (3)$$

The mathematical expression of PSNR is as follows:

$$\mathrm{PSNR} = 10 \times \lg \frac{255^2}{\mathrm{MSE}}. \tag{4}$$

In general, the edge corresponds to high-frequency information, while the flat point corresponds to low-frequency information, and the noise corresponds to high-frequency information [27]. How to distinguish the noise information in the high-frequency band is the key to keeping the edge information and removing the noise [28]. The paper-cutting patterns were constructed by using the spline curve, and then the paper-cutting images were generated by combining the patterns to obtain the paper-cutting patterns with ethnic style [29]. The paper-cutting design module consists of three parts: drawing parameter setting, common graphics drawing, and pattern drawing, as shown in Figure 2.

Secondly, the grayscale image is divided into two grayscale regions, one of which is set to 0 and the other is set to 1, so as to prepare for more accurate edge extraction. From the viewpoint of modern visual communication design, the paper-cut pattern organizes the natural objects located in a different time and place according to a clear design intention and transforms the three-dimensional world into a two-dimensional paper surface. By calculating the center-of-mass position of each color grouping, the location information of the pixels is incorporated to make the tracking more accurate and rapid. To calculate the center of mass of each color unit i:

$$K_i^n = \frac{\sum_{i=1}^{n_h} \delta[b(X_i) - u] X_i}{\sum_{i=1}^{n_h} \delta[b(X_i) - u]}. \tag{5}$$

n is the n frame image, X_i is the pixel position in the target area, μ is the histogram color value, and $b(X_i)$ is the color value of pixel.

For edge information, the pixel values of the images at these locations change drastically, and the gradients corresponding to their gray functions are larger at the edges and smaller at the nonedges of the images, where the gray scale does not change much. A suitable threshold is found to binarize the whole image, and then a concatenation algorithm of disconnected regions is used. However, when edge detection is performed, image blurring and the presence of noise can lead to a wide or broken edge somewhere. Therefore, the image is corrupted with this structural element, and then the corrupted result is subtracted from the original image to obtain the image boundary.

Finally, a threshold is determined before binarization, which is used to segment the object area and the background area after the image is filtered. To set the threshold, pixels with a brightness value greater than the threshold are set to white, and those below the threshold are set to black. Paper-cut patterns do not have light and shadow effects, but the organization of dots, lines, and surfaces, the black and white contrast of yin and yang engraving, does not lose the richness of the hierarchy and sense of rhythm, this special medium and expression of paper-cut patterns determine its flat two-dimensional modeling characteristics. A digital image often contains a wealth of information. According to the image edge characteristics to divide, we can divide these information into two parts: edge information and non edge information, in which the non edge information and the image itself containing noise points change more smoothly. For the target pixel in the binary image, if after removing it, its 10 neighboring pixels can still form a closed boundary line, and the position and shape of the boundary line are not affected, the pixel can be considered as not a boundary pixel.

3.2. Paper-Cut Pattern Design Based on Image Restoration Technology. The traditional method requires a large amount of work if various types of patterns are to be designed and requires the operator to have a certain foundation of artistic creation to achieve it. Paper-cut pattern design based on image restoration technology organizes natural objects located in a different time and place purposefully according to a clear design intention and transforms the three-dimensional world into a two-dimensional paper surface, forming a way of thinking and observation that is compatible with plastic arts. A large number of restoration models, as well as image restoration algorithms, have been proposed. Currently, there are two main representative image restoration algorithms, and the image restoration technology approach is shown in Figure 3.

First, the basic feature symbols are extracted from the existing paper-cutting patterns. In the subsequent cropping of the paper-cut pattern space, the edges of the image are cropped in one direction, counterclockwise, or clockwise. Cropping in the counterclockwise direction will keep the image part inside the edge, while cropping in the clockwise direction will crop out the area inside the edge. In general, blocks to be repaired with high confidence values should be repaired first so that the repair process is more reliable, and the confidence level is defined as follows:

$$C(p) = \frac{\sum_{q \in \psi_p \cap \varphi} C(q)}{\left|\psi_p\right|}. \tag{6}$$

$C(p)$ is the confidence level and $|\psi_p|$ is the area of ψ_p.

However, the design of paper cutouts requires a comprehensive consideration of various factors such as the lightness and darkness of pixels, the strength of edges, and the overall connectivity, etc. The threshold-based approach to determining the skeletonization property of each pixel based only on the lightness and darkness of pixels is obviously not in line with the artistic characteristics of paper cutouts. So it is an essential process for image extraction. Because the gradient reflects the degree of the color change of pixel points, the gradient magnitude of all known points in the block to be repaired can represent the structural information of this region to a certain extent. Therefore, in the patching, it is only necessary to implement the patching in the direction of the iso-illumination line, and whether the gradient rotation direction is clockwise or counterclockwise does not have a significant impact on the patching effect, but only needs to ensure the direction of change of the minimum gray value. The bilateral filtering kernel is constructed by multiplying a Gaussian kernel function in the null domain

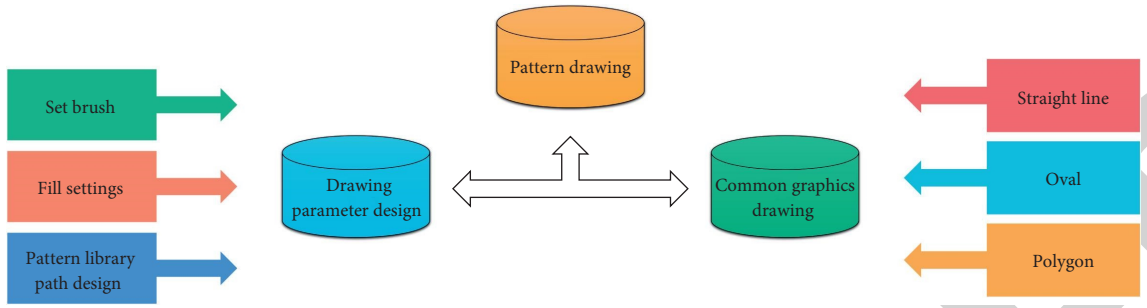

Figure 2: Paper-cutting design process.

(spatial Gaussian kernel) with a Gaussian kernel function in the value domain (luminance Gaussian kernel):

$$g(x) = \frac{1}{C_{d,\gamma}} \sum_{x,y\in\Omega} w_d(x,y) w_r(x,y) f(x). \tag{7}$$

$f(x)$ is the original image, $g(x)$ is the output image, $w_d(x,y)$ is the spatial information weight function, and $w_r(x,y)$ is the gray similarity weight function.

Therefore, the position of the center of the local neighborhood is continuously shifted with the distribution of the initial samples until the entire iterative process ends when the position of the center hardly changes anymore.

$$C(p) = C(\hat{p}), \forall q \in \psi_p \cap \varphi. \tag{8}$$

$\hat{p}$ is the center point of the new block to be repaired.

Image edge tracking is to use the edge connectivity to arrange the closed curves of individual edges in one direction counterclockwise or clockwise, pixel by pixel, and store the position of each pixel, i.e., the horizontal and vertical coordinate values. The gray number of the image is divided into 2 parts by gray level, and the optimal threshold is found by calculating the maximum value of variance between classes so that the difference in gray value between the two parts is maximized:

$$p_i = \frac{n_i}{N}, \quad (i = 0, 1, 2, \ldots, L), \qquad \sum_{i=0}^{L} p_i = 1. \tag{9}$$

N is the total number of image pixels, n_i is the number of pixels with gray level i, and p_i is the probability of gray level i in image.

The subsequent repair process relies on nonlinear diffusion so that those colors that are randomly filled in the defaced area can appear in contrast with the surrounding area by diffusion. The direction of the maximum gray change in the image corresponds to the gradient, while the direction of the minimum change in gray is perpendicular to the gradient. By simply changing the operators of $C(p)$ and $D(p)$ to summation and introducing the weights α, β for weighting, respectively, the improved priority calculation formula is as follows:

$$P(p) = \alpha C(p) + \frac{1}{\beta} D(p), \tag{10}$$

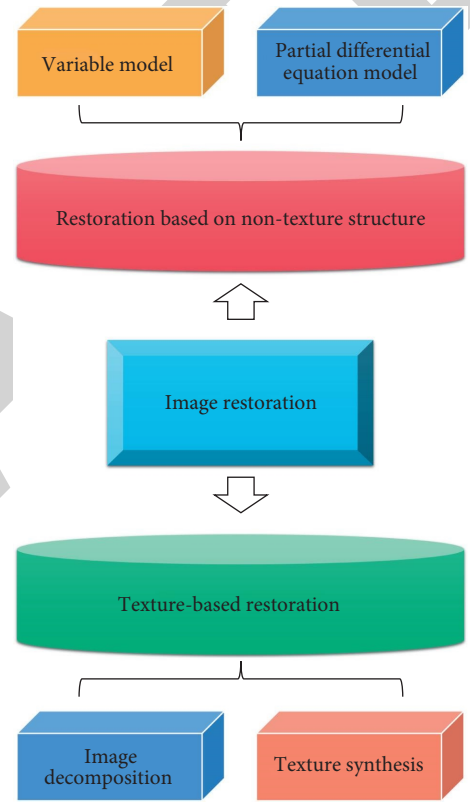

Figure 3: Image restoration techniques and methods.

$D(p)$ the data item.

Finally, the basic graphic elements are decomposed from the paper-cut pattern, and the graphic elements that do not exist in the existing pattern are generated based on these graphic elements. It obtains the coordinate value of a pixel in a certain direction by adding the coordinate value of the center pixel to the offset corresponding to that direction so as to realize the traversal and judgment of this pixel value. In other words, iterations occur at the edge pixels of the waiting repair area, and the actual update area advances one pixel in the waiting repair area with each iteration. If the number of nonzero elements in the signal is much less than the number of zero elements, the signal is said to be sparse. And in reality, generally, natural signals are not sparse. However, we can perform a sparse representation of the signal in the overcomplete dictionary to get an approximate sparsity.

After each image restoration, we have to run the anisotropic diffusion several more times, and in this way, we keep the correctness of the information transfer at the boundary of the broken region and reach the smoothness of the image edges.

4. Application and Analysis of Image Restoration Technology in Paper-Cut Pattern Design

4.1. Analysis of the Criminisi Image Inpainting Algorithm. The Criminisi algorithm introduces the concept of repair priority for the first time and uses the structural information of the image as a reference for the image repair order, making the repair order of the algorithm more reasonable. If the graphic elements are replaced, or curve fitting is used, a large number of paper-cut patterns of various forms can be generated. The advantage of curve fitting is that the more complex curves can be obtained by giving enough control points. An example of curve fitting is shown in Figure 4. The ordinate in Figure 4 is the peak signal-to-noise ratio: the ratio of the maximum possible power of the signal to the destructive noise power that affects its representation accuracy.

Based on the edge information of the area to be repaired, the information from the known area of the image is diffused into the area to be filled along the direction of the iso-illumination line and using the diffusion mechanism. In other words, in the image restoration process, several iterations of diffusion should be performed for each restoration step, and the diffusion is to avoid curve crossings. Each diffusion process fills the data information generated by the previous diffusion into the broken area, and then the global statistics of the filled image are performed using a Bayesian model. It is used to estimate the next diffusion coefficients and generate new data for the next iteration based on the new diffusion coefficients until the image restoration is completed. The PSNR values and restoration times of the Criminisi algorithm were compared with the TV model restoration and the FMM algorithm restoration, and the results are shown in Table 1.

Next, the priority of the block to be repaired, determined by all pixel points on the broken edge, is calculated according to the priority formula defined by the algorithm, and then the block with the highest priority is selected by comparison as the starting block for image repair. In the pure white initialization, there is no information in the area waiting to be repaired, and the gray value of each point in the replacement area needs to be gradually passed through the points at the edge location of the area, which is obviously very unfavorable to the repair work. Therefore, not only the confidence term is considered when calculating the priority, but also the weight coefficient is added. The size of the weight coefficient is related to the iso-illumination line of the points at the edge of the region to be repaired, and the iso-illumination line can represent the propagation of the structural information (Figure 5).

Since the change of image gradient reflects the change of image spatial frequency, i.e., it can reflect the local

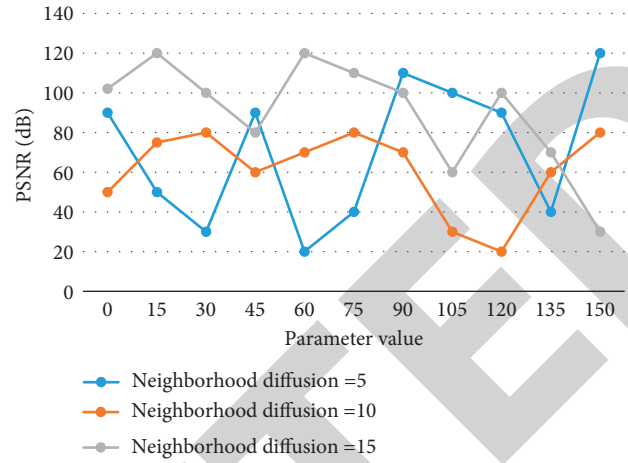

Figure 4: Example of curve fitting.

Table 1: Comparison of PSNR value and repair time of different algorithms.

	Criminisi	TV	FMM
PSNR	24.987	31.255	45.982
Repair time	1.98	1.65	0.47

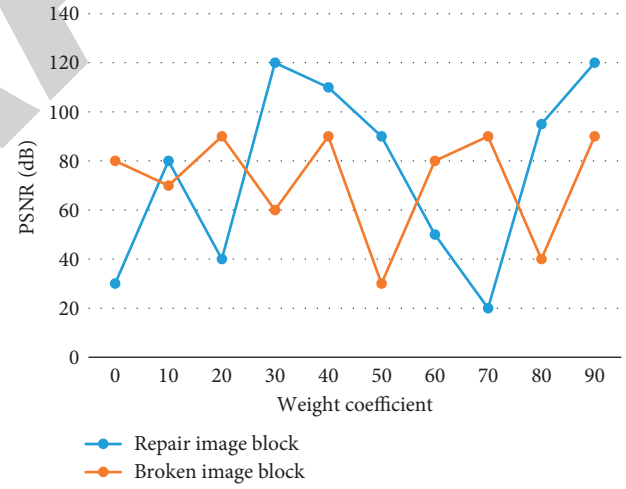

Figure 5: Comparison of PSNR values.

characteristics of the image, the sample block size is determined adaptively according to the gradient value size. However, since the selection is based on the sum of the smallest equal illumination lines, if the defective area contains relatively thin lines, it is likely to be truncated during the restoration process, thus destroying the visual connectivity principle. So the atoms found by traversing the dictionary in each iteration with the highest similarity to the signal are orthogonalized, and such an operation avoids repeated selection of atoms in the image and improves the accuracy of the priority solution.

Finally, a global search is used to find a matching block within the known region that is most similar to the texture

information of the block to be repaired using the SSD matching criterion, and then the corresponding pixel information in that block is copied and filled into the block to be repaired. The pure white initialization prompts the individual points within the rest to have all 0 propagation, and it is only the points waiting for the edge locations of the repaired region that can rely on the residual information to get the propagation and further update the values. The digital image restoration process is mainly to keep the edge information as much as possible while restoring the image, try to keep the rate of change of the image edge in the gradient direction during the image smoothing process, and try to make a large smoothness in all directions at the nonedge points so that a good repair of the broken image can be achieved.

4.2. Analysis of Image Damaged Edge Reconstruction. To obtain good image restoration results, it is necessary to first constrain the restoration of image structure information, i.e., to connect and continue the image edge information accurately and effectively and to ensure that the part to be restored with significant structural features can be restored first.

First, as an important basis for fracture point matching, the color feature mainly describes the color composition of the neighborhood of the defective region, while the curvature information describes the extension direction of the defective structure of the image. Priority is given to repairing structural information and information in the vicinity of structural regions. Before repairing a broken image, an anisotropic smooth diffusion of that image is performed in advance, with the purpose of eliminating the effect of noise on the whole repair process, after which the alternating cycle of repair and diffusion is entered. The texture of the image, especially the texture to be filled in the area to be repaired, is a very irregular texture, which is relatively messy. Therefore, we want to add the amount of information in the area to be repaired and give the initial values to the internal points, thus increasing the iteration speed with a large number of points getting the conductivity and expecting to improve the repair effect. Instead of deciding pixel by pixel whether to skeletonize or preserve, the paper-cut pattern generation task calculates the skeletonization properties of each segmented region, i.e., whether to skeletonize the whole. A comparison of the feasibility of the algorithms in this paper is also performed using 20 sets of images from the OTB-2020 dataset, where the comparison algorithm is CSK. Finally, the tracking accuracy graph shown in Figure 6 and the tracking success rate graph shown in Figure 7 are obtained.

Secondly, the isolated fractured edges without matching edge lines are then extended naturally according to their curvature until they intersect with known regions or reconstructed edge lines. That means the smaller the value of the data term and gradient term in the priority, the easier it is to get a good repair effect. In the image restoration process, the good or bad image edge combination directly affects the quality of image restoration, and the biggest advantage of overall variation is that it overcomes the shortcomings of

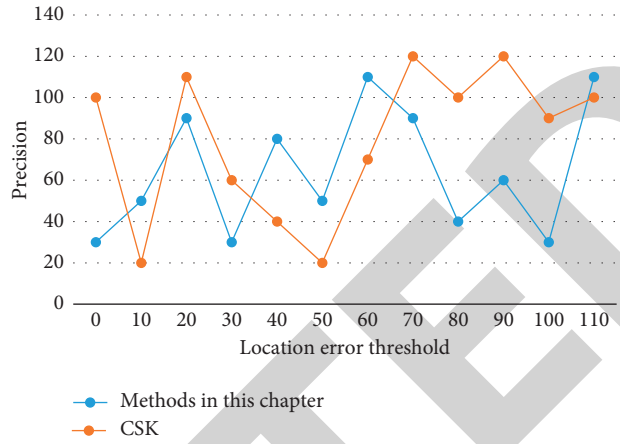

Figure 6: Comparison chart of ope accuracy.

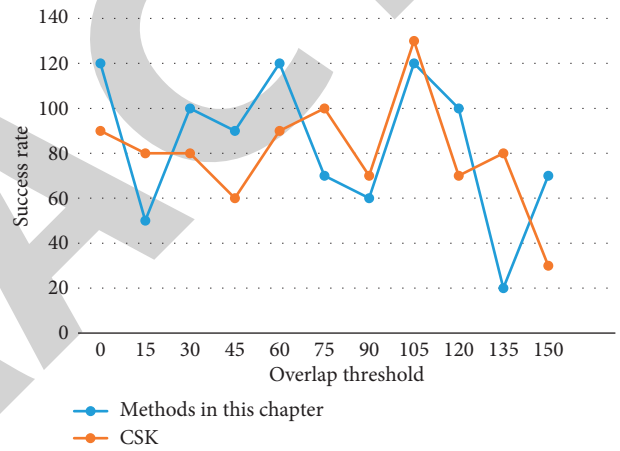

Figure 7: Comparison chart of OPE success rate.

linear filtering in suppressing noise while smoothing image edges, which does not change or sharpen image edges while suppressing noise. At the same time, if there are fewer known points in the target block, i.e., the smaller the confidence term, the less edge information it contains and the easier it is to match. If the skeleton properties of adjacent regions are different, the boundary between them will be preserved in the final cutout figure. The running time of image broken edge reconstruction, CDD algorithm, and FMM algorithm are compared, and the results are shown in Table 2.

Compared with the CDD and FMM algorithms, the image broken edge reconstruction lengthens the runtime by 27.7 s and 38.5 s. Both MSE and PSNR are well improved, indicating that the image broken edge reconstruction effectively improves the restoration results while running fast.

Finally, the process of edge reconstruction is consistent with the process of curve fitting, which is the process of connecting mutually independent points with a smooth curve, i.e., estimating the trend of the curve using the few known information around the broken edge. A paper cutout has only two colors, while the input image contains thousands of colors. Unlike sound and text, images have a more

Table 2: Reconstruction of the damaged edge of the image, comparison of running time between MSE algorithm and PSNR algorithm.

Parameter	FMM	CDD	Image damaged edge reconstruction
Run time (s)	17.7	28.5	56.2
MSE	0.1173	0.1182	0.2673
PSNR (dB)	57.10	59.36	62.88

visual representation, so they can be said to be the most objective reflection of things. For images, the lower the priority, the higher the chance of matching the target block successfully and the better the repair effect, so choose to repair the block centered on the point with the lowest priority each time. In the process of image restoration, the overall variance model can be used to preserve the edge information of the image while minimizing the total variance of the image to achieve the restoration of the degraded image. To transform an image into a paper cutout, it is actually a matter of determining whether to take the foreground color or the background color for each segmented region. Therefore, the image can be converted into a grayscale image by color quantization, and finally, the image is converted into a binarized image suitable for system processing. The edge reconstruction takes into account the continuity of the structural information of the edges of the broken areas in the image and the preservation of the texture information while repairing the broken areas, which ensures the natural texture and structural coherence of the broken areas after the image repair.

5. Conclusions

(1) Chinese traditional folk paper-cut patterns are created by working people to meet the needs of their own spiritual life and express the passionate and simple feelings of ordinary people. It is not only a kind of manual paper-cut art but also contains China's economy, politics, culture, life, folk customs, spirit, religious beliefs, and other intangible civilizations. It has become an important reference for the study of history and culture. Based on the existing research results, this paper deeply analyzes the characteristics of manual paper-cut art and puts forward a paper-cut pattern design method that uses image restoration technology to improve the above methods.

(2) Image restoration is actually a process of filling the damaged part with the known information in the image and obtaining the results that conform to the human visual characteristics through certain methods. This paper presents a paper-cut pattern design method based on image restoration technology and analyzes the reconstruction of image broken edges by the classical Criminisi algorithm based on texture synthesis. The algorithm not only makes the information near the area to be repaired diffuse inward according to the isoilluminance line so as to repair the image but also effectively balances the noise while ensuring the image edge. Edge reconstruction considers the continuity of the edge structure information of the damaged area in the image and preserves the texture information when repairing the damaged area, which ensures the natural texture and structure consistency of the damaged area after image repair.

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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