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Research on Artificial Intelligence in New Year Prints: The Application of the Generated Pop Art Style Images on Cultural and Creative Products

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Abstract: Chinese New Year prints constitute a significant component of the country's cultural heritage and folk art. Yangliuqing New Year prints are the most important and widely circulated of all the different kinds of New Year prints. Due to a variety of factors including societal change, industrial structure change, and economic development, New Year prints, which were deeply rooted in agricultural society, have been adversely impacted, and have even reached the brink of disappearance. With the protection and effort from the government and researchers, New Year prints can finally be preserved. However, the underlying problems remain, such as receiving little attention, a singular product form, and being unable to keep up with the times, especially among the younger generation. In this paper, the researchers first processed Yangliuqing New Year prints through the GANs model. Then, the image is segmented by binarization and color extraction of images from the Pop art dataset by the K-Means algorithm, followed by colorizing the binarized and segmented image. Finally, usable high-quality Pop art style Yangliuqing New Year prints are generated. The generated images are used in the development of cultural and creative products. Questionnaires were then distributed based on the empirical research scale. The results of this study are as follows: 1. The method proposed in this study can generate high-quality Pop art style New Year prints. 2 Using Pop art style New Year print images in the design of cultural and creative products is popular among the younger generation, and they possess a great propensity to purchase. This study solves the problems encountered by the current cultural heritage of New Year prints, and broadens the artistic expression forms and product categories, and provides research ideas for the cultural heritage of the same type that is facing similar problems. In the future, researchers will continue to explore the incorporation of AI technology in New Year prints to stimulate the vitality of traditional cultural heritage.

Keywords: Yangliuqing New Year prints; cultural heritage; artificial intelligence; deep learning; pop art; style transfer; cultural and creative products

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1. Introduction

1.1. New Year Prints Background and Problem Statement

The New Year prints (also known as New Year pictures or New Year paintings) are traditional folk works of art in China and are popular among Chinese people in the countryside. In ancient times, when the year-end came, every house would put up New Year prints and couplets, to enrich festivity, pray for blessing, usher in good luck, and avoid disasters. New Year prints are folk art varieties with the largest circulation, the greatest influence, the highest cultural content, and the richest regional styles in ancient China, but it is also the most serious folk culture facing extinction today. In 2002, New Year prints were included in the first batch of the rescue list of "China Folk Cultural Heritage Rescue Project", and in May 2006, New Year paintings were approved by the State Council of China to be included in the first batch of the national intangible cultural heritage list [1]. New Year prints receive their name because they are replaced once every year, or they are

supposed to last a year once put up. Traditional New Year prints are typically block printed with colored paints. Therefore, the New Year prints are also called China Woodblock New Year prints. New Year prints can be traced back to 200 BC [2]. They are not only colorful decorations during the festival, but also reflect the history, life, beliefs, and customs of Chinese society. They have presented a full picture of Chinese people's spiritual world. Therefore, New Year prints not only have great value as works of art, but also contain rich cultural meanings.

Globally, New Year prints not only exist in China, but are also collected by other countries, including Russia, Japan, UK, Czech Republic, Canada, France, etc. Among them, Russia and Japan are the countries with the largest collection of New Year prints, and they are also the two countries with the most in-depth research on New Year prints [3]. There are more than 600 high-quality New Year prints in the collections of various museums in Russia. Moreover, Russian scholars studied New Year prints earlier than Chinese scholars. The most famous scholar is Academician Li Fuqing (Riftin), who has written many works related to New Year prints. He devoted his life to the study of Chinese mythology, folk literature, New Year pictures, and the history of cultural exchanges between China and Russia [4]. In Japan, it is more about the Taohuawu New Year prints collection. There are many really valuable New Year prints in the collection, and even some New Year prints that were once in China have been lost. At the same time, Japanese scholars have also contributed many achievements in the study of New Year pictures, including Japanese scholars Miyama Ryo, Hiroyuki Takimoto, Ryo Nakazuka, etc. This makes for a very in-depth analysis of the theme, culture, technique, aesthetics and other aspects of New Year prints. Due to Japan's policies and regulations on cultural heritage protection being ahead of the rest of the world, the country has a highly thorough preservation of New Year prints. Japan began actively protecting its cultural heritage in the fourth year of the Meiji period (1871). The Meiji Restoration had a significant impact on every aspect of Japanese society and presented significant difficulties for the country's indigenous traditional culture. In this context, Japan promulgated a number of laws to protect heritage, and with the development of society continues to improve. These are very worthy of our study and reference [5].

Due to the different places where the New Year prints are made, the image presented and the customs reflected in the New Year prints are also different. Professor Feng Jicai divided the New Year pictures into 19 categories according to the gathering places of New Year pictures, corresponding to the 19 production areas of New Year pictures as marked in Figure 1 [3]. The Yangliuqing New Year prints or Yangliuqing Woodblock New Year prints were named after the Yangliuqing Town of Tianjin where they originated (Figure 2). The Yangliuqing New Year prints became popular during the reign of Emperor Chongzhen around 1628 at the end of the Ming Dynasty (1368–1644) and flourished during the reigns of Emperor Yongzheng, Qianlong, and Jiaqing (1723–1820) during the Qing Dynasty (1644–1911). Heritage today has a history of more than 400 years [6].

After China's reform and opening up, people's lives and production have also undergone great changes. Obviously, the culture also keeps changing in this progress. Clifford Geertz pointed out that culture consists of socially established structures of meaning in terms of which people do such things as signal conspiracies and join them or perceive insults and answer them; this is no more to say that it is a psychological phenomenon, a characteristic of someone's mind, personality, cognitive structure, or whatever [7]. However, it seems we cannot equate culture with a psychological phenomenon, since culture is often an all-encompassing concept. A splendid culture is created by people from all segments of society, and it is hard to distinguish the influence of various levels of society on culture. However, it is certain that with the change of economic situation and social structure, Yangliuqing New Year prints have the corresponding transformation in the new period.

Figure 1. Nineteen origins of New Year prints.

Figure 2. Partial Yangliuqing New Year prints.

For a hundred years, Chinese society has gradually shifted from a farming society to an industrial society, transformed from a traditional society to a modern society, and from a rural society to an urban society. Overall, this transformation is apace and huge, thus many traditional cultures have no time to react and fall into an embarrassing situation that is about to disappear. An obvious example is folk culture and art, ancient traditions with a long history, where it is extremely difficult to keep up with the rapidly changing modern society [8]. Especially intangible cultural heritage is most likely to be impacted and disappear during the transition process. Among them, the most influential is the New Year prints. At the same time, at the end of the 19th century and the beginning of the 20th century, China has suffered from wars and aggression for years, and the people were displaced. Many excellent traditional New Year prints were lost and destroyed during the war. This is also one of the severe difficulties faced by the art of New Year prints.

The New Year prints cultural heritage rescue work presided over by Professor Feng Jicai began in 2001. After ten years, Chinese New Year prints were sorted and collected, and the New Year pictures research institute was established. Additionally, they published some books, collected and photocopied New Year prints, and established digital archives. However, although these works protected the New Year prints, they did not change

the situation of their gradual decline [9]. As a kind of folk art, New Year prints are mainly created, inherited, and sold by inheritors of folk cultural heritage. Therefore, it is completely possible to explore its survival status from the sales situation. The researchers surveyed many shops set up by inheritors of Yangliuqing New Year prints. These shops are Rongfu Painting Store, Nianhua Zhang Painting Store, Yingbaoge Painting Store, Wang Painting Store, and Youyuanlong Painting Store. Through interviews with shop owners and intangible cultural heritage inheritors, they came to understand the problems faced by New Year prints. Due to the novel coronavirus pneumonia epidemic in 2020, the situation from 2020 to 2022 will not be included for reference.

Rongfu Painting Store was founded in 2002. At that time, it opened two stores with nine employees. The main buyers were large-scale purchases by government enterprises, local people's purchases during festivals, and tourist purchases. However, from 2014 to 2019, sales have declined year by year, and now it has been reduced to one store, no longer employing employees and replaced by family members, the purchase volume of the government and enterprises has dropped sharply, and the public and tourists rarely buy either. The owner Cao Fulin said that during the peak sales season in 2018, no one bought New Year prints for nearly a month. The overall purchase volume is also decreasing year by year. The Nianhua Zhang Painting Store and Yingbaoge Painting Store are also facing the same problem. Wangji Painting Store and Youyuanlong Painting Store even disclosed their business sales to the researchers, as shown in Table 1. From around the 2010s, it was mainly wholesale in large quantities, and now it is mainly retail. The net profit has not changed much in the past few years. Considering inflation and economic development, it can be said that the sales volume and income have declined. Cao Minggang, the owner of Youyuanlong Painting Store, believes that the main reason for the decline of New Year paintings is that traditional culture is not loved by the people and is no longer very attractive. Moreover, the main consumers of New Year pictures are mainly older people, and now it is almost impossible to see young people entering the store for consumption.

Table 1. Wangji Painting Store and Youyuanlong Painting Store sales situations.

Wangji Painting Store			
Year	**Net Profit (¥)**	**Retail Proportion**	**Wholesale Proportion**
2009	About 150,000	30%	70%
2019	About 200,000	70%	30%
Youyuanlong Painting Store			
Year	**Net Profit**	**Retail proportion**	**Wholesale proportion**
2011	About 80,000	20%	80%
2018	About 60,000	95%	5%

Through literature, interviews, and summaries, the reasons for the current problems of New Year prints are mainly caused by three factors. One is social changes. New Year prints used to be the main way of aesthetic entertainment in agricultural society festivals. However, in today's information society, the rise of various smart products has made New Year prints unable to meet the entertainment needs of the people, which has led to the rapid decline of New Year prints. The second is the change in the function of New Year prints. As a way for people in the agricultural society to obtain new things, New Year prints have the function of "ethical education", which can be found in New Year prints' artworks. In today's society, people's education level is gradually improving, and compulsory education has been fully popularized, so New Year prints are no longer needed to spread virtues. The posting of New Year prints also has the function of "warding off evil spirits", such as door gods, kitchen gods, etc.; however, due to the high degree of urbanization in China at present, a large number of people have moved to apartments. New Year prints created for the living environment of agricultural society can no longer meet the posting requirements of the current living environment. The third is the singleness of the art form of New Year

prints. From ancient times to the present, New Year prints are mainly displayed and sold in the form of paintings. Except that the content changes with the changes of society, the form and style of the pictures are relatively single. This has caused a certain aesthetic fatigue for users, especially young people.

To sum up, to solve the current problems faced by Yangliuqing New Year prints, it is necessary to make changes in the artistic language and form. New Year prints are a kind of traditional cultural heritage. In addition to conducting protective research on them, we also need to explore how to innovate and develop them. Due to the low attention paid by young people and the single art form of Yangliuqing New Year prints, we need to change the display method of New Year prints and introduce other art forms and creative means, and develop related cultural and creative products to gain the favor of young people, so that New Year prints culture can be better disseminated and promoted.

1.2. The Similarity between Pop Art and New Year Prints Art

Pop art originated in England in the middle of the twentieth century, developed rapidly in the United States in the 1960s and became prosperous [10]. At that time, international politics tended to be stable, people's living standards were greatly improved, and their purchasing power also increased. Young people became the main consumers. To attract young consumers, merchants quickly updated advertising ideas through modern media, which provided creative inspiration for artists at that time [11]. The pop art style is derived from the expression form of pop art and regards mass culture as its only cultural and artistic resource. Pop Art reflects the formation of Western consumer society and the profound influence of mass culture on art [12]. Richard William Hamilton, the British artist, once summarized the characteristics of Pop art as popular (designed for the public), transient (short-term program), expendable, low-cost, mass-produced, young (targeted at youth), witty, sexy, gimmick, glamorous, and Big Business, stressing its everyday, commonplace values [13,14].

Similarly, the art of New Year prints is also based on the growing consumption and spiritual needs of the public, reflecting the art of public life. Although the art of New Year prints and Pop art were produced at different times, in different regions, and with different cultural connotations. However, there are numerous similarities between the two since they both value popular culture, have popular tastes, and follow a cultural or economic model that can be mass-produced:

1. The objects of Pop art and New Year prints art are both popular art with the masses as the main group. The objects of their creations and consumer groups are all ordinary people in society, and they are extremely universal;
2. Both Pop art and New Year pictures are oriented toward practical value, with a clear usage tendency. The subjects of New Year prints, including children, operas, door gods, kitchen gods, etc., all serve to satisfy the public's desire to prevent calamities, spread morality, and pursue beauty. Most of the creative symbols and elements of pop art are directly drawn from ready-made materials, closely following the trend of the times, and also meeting people's preferences and needs at that time;
3. The creation methods of Pop art and New Year prints are mainly influenced by prints, which can be mass-produced through printing.

In summary, there are many similarities between Pop art and New Year prints. One of the main characteristics of Pop art is that it is geared toward young people and is trendy, which is exactly the problem that Yangliuqing New Year prints is currently encountering and urgently needs to be resolved. Therefore, at the level of innovation in the art form of Yangliuqing New Year prints, we can make the art of New Year prints younger and trendier by referring to the Pop art style and win the hearts of more young people.

1.3. Some Attempts Made by New Year Prints in Artistic Innovation

Bai and Ma in 2021 proved that studying the fusion and innovative design of Picasso style and Yangliuqing New year prints is conducive to the innovation and inheritance

of Yangliuqing New Year prints. Therefore, we need to find a place where they meet, to arouse the public's passion in a more appealing form. Due to the change in the aesthetic trend of young people, the inheritance and development of Yangliuqing New Year prints are not optimistic. At this stage, people pay more attention to innovation. The current Yangliuqing New Year prints have problems such as single cultural derivatives, few forms of expression, homogenization of content, and lack of innovation [15]. In their research, they believe that it is necessary to meet the cultural and psychological needs of modern design, and to ensure the fusion and innovative design of Yangliuqing New Year prints on the basis of its ontology. Only by organically combining Yangliuqing New Year prints with a modern painting style can the cultural and creative products of Yangliu Qingnian painting maintain vitality forever.

In Liu's research, based on semiotics theory, he extracted the New Year prints element, combined it with product design, and designed home lamp products. He thinks that understanding intangible cultural heritage outside characteristics and inside culture and applying these to the design of cultural and creative products can improve the attention and popularization of intangible cultural heritage in public [16].

Zhao et al., in 2022, chose to extract suitable auspicious elements for innovation by using the method of direct application, element extraction, and style innovation. Provided that the innovative application of using New Year prints in modern design is of great significance for the inheritance of intangible cultural heritage, the improvement of the public's aesthetics, and the effective expression of design emotion [17]. They believe that by extracting and deconstructing folk culture elements, and then using modern design thinking to redesign, not only can the cultural connotation and national characteristics of traditional art be preserved, but also innovative forms and artistic expressions can be made more vital.

Some other researchers have explored the art form of New Year prints. For example, in 2020, Yang carried out illustration design by extracting the elements of Yangliuqing New Year prints [18]; in 2021, Liu studied the color and characteristics of the cultural heritage of New Year prints and applied them to clothing design [19]; in 2019, Chen analyzed the color of Yangliuqing New Year prints, and extracted and applied it to the color design of the other product [20], etc. The above lists the innovations and attempts made by researchers on New Year prints in the past three years. The researchers have put forward their personal views and innovative methods based on the problems faced by New Year prints, including the fusion of styles, the extraction of elements, etc. The similar conclusions of the above studies are all based on the culture of New Year prints. Combining with modern design, innovations in its forms of expression and related products will attract more people's attention, especially the younger generation, and cause them to pay more attention to the culture of New Year prints.

However, these studies have some shortcomings. The result of the design is extremely dependent on the designer's level of ability and aesthetics, and it is difficult to reproduce and produce in large quantities. New Year prints require a technology that can quickly generate new forms and styles, and the new forms and styles generated are controllable, stable, fast, and can be reproduced and produced in large quantities. The current way to meet these characteristics is to use AI tools to generate them. A model is proposed through deep learning and computer vision. This model can quickly generate New Year prints with a new artistic style conveniently and fast. It allows users to participate and submit their favorite New Year prints for a generation. These generated images can be used for sale on related cultural and creative products, diversifying the art form of New Year prints.

In conclusion, this section analyzes the background and present circumstances to describe the issues that Yangliuqing New Year prints are currently facing. The main problems are that the art form and products are traditional and single, their original purposes are no longer relevant in modern society, and they are unable to capture the interest of young consumers. In this paper, researchers try to solve these problems. First, Lu proposed a migration of a digital image art style based on a deep learning model in

2022, using YOLO v3 model to quickly identify and locate, then use classical semantic segmentation algorithm to delineate, and finally use variational autoencoder to generate the migrated Chinese style picture. This study solves the problem of poor region delineation and boundary artifacts in Chinese style migration of images [21]. At the same time, in the research article by Mariati et al., the exploration of narrative and artistic style in mural design is mentioned. They believe that the art style needs to be extremely attractive, and the visual effects need to be unique in order to attract the attention of visitors. In the article, it was found that Realism, Decorative Patterns, Expressionism, Surrealism, Art Deco, Futurism and Pop art attracted the most attention [22]. The articles of these researchers inspired the authors. Therefore, in this paper, the author used deep learning and computer vision to quickly and stably generate Pop art-style images that are popular with young people. Secondly, designs based on the most popular cultural and creative products among young people increase the product form of Yangliuqing New Year prints and strengthen publicity and promotion. However, the author's intention is not to use artificial intelligence to replace New Year prints makers. As we all know, traditional folk art is inseparable from the efforts and production of cultural inheritors, and folk culture cannot be separated from the context in which it was born. The purpose of this research is to combine traditional culture with artificial intelligence technology and expand its form of expression, so as to attract the attention of contemporary young people and arouse their interest in New Year prints. This will allow them to better comprehend New Year prints culture. In addition, New Year prints art-related products expanded through artificial intelligence technology can enrich the product types of New Year prints and increase the income of New Year prints practitioners. In this way, a virtuous circle is obtained, which is more conducive to the inheritance and development of current New Year prints.

The paper structure is as follows: In the second section, the researchers conducted a literature review on the application of AI technology in cultural heritage. In the third section, the researcher introduces the method used to generate the Pop art style of New Year prints. In the fourth section, the researchers determined the four most popular cultural and creative products through the literature review on the development of cultural and creative products and the statistics of the sales volume of online stores. A questionnaire survey was conducted on the cultural and creative products designed by the researchers, and the results were obtained. The fifth section concludes and discussed this paper and puts forward the directions for further in-depth research by researchers in the future.

2. Introducing Artificial Intelligence to Cultural Heritage

The development of artificial intelligence and computer vision technologies in recent years has led to the application of AI in the protection, restoration, and archaeology of cultural heritage sites. For instance, AI is used to automatically recognize ancient characters [23], identify archaeological ceramics from worldwide digs [24], and create sketches for ancient mural paintings [25]. In the current research on the combination of cultural heritage and artificial intelligence, researchers have conducted research and discussions in various fields such as feature recognition, style transfer, etc.

In the style transfer, a research foundation for embroidery digital study and preservation is supplied by Qian et al.'s conversion of the provided photos into traditional needlework styles using CNN and semantic segmentation. Based on a convolutional neural network (CNN), they suggest an embroidery-style transfer technique from a 2D image and assess the pertinent rendering elements. The suggested technique may not only replicate fine lines and needle textures, but can also provide stereoscopic effects to mimic the appearance of real needlework characteristics [26]. According to Chung et al., through the GAN model, Chinese ink paintings are converted into real-style images, and references for different styles are provided. They built a border improvement by combining cycle-consistent GAN with pix2pix and adding a label function GAN to improve border detail and create more accurate and realistic images [27].

In feature recognition, the feature recognition of cultural heritage mainly includes 2D feature recognition (graphics, text, etc.), and 3D architectural cultural heritage recognition. In 2019, Wuchai used the CNN model to identify Thai traditional cultural graphics -Phasin, Hand-Woven Fabric Pattern, three deep learning models experimented: Inception-v3, Inception-v4, and MobileNets. The test accuracy rates of pattern design recognition for MobileNets, Inception-v3, and Inception-v4 are 94.19, 92.08, and 91.81%, respectively [28]. Zhao in 2022 used DeepLabv3+ to perform semantic segmentation of Xiangjin art, which can better digitally research and save the art graphics of Hunan embroidery [29]. Fu in 2021 proposes a CNN model for feature extraction of traditional cultural patterns for image restoration [30]. Robert et al. promote the digital management of cultural heritage by using CNN to perform semantic segmentation of historical buildings. The semantic segmentation of Point Clouds is a relevant task in DCH, as it allows us to automatically recognize different types of historical architectural elements, thus possibly saving time and speeding up the process of analyzing Point Clouds acquired on-site and building parametric 3D representations. In this paper, they provide a first assessment of state-of-the-art DL-based Point Cloud segmentation techniques in the Historical Building context. Through the modification of the CNN model, it has high accuracy in the identification of historical buildings [31].

Based on the exploration of previous researchers, we learned that it is feasible to use AI in the direction of cultural heritage. It is not only necessary to study how to optimize algorithms and models, but also to put forward practical solutions based on existing AI models and cultural heritages that encounter practical problems and apply AI technology to cultural heritages to address the issues they are now facing.

3. Method

In the first section, we know that one of the characteristics of Pop art is aimed at young people, and Pop art and New Year prints are similar in many ways. Based on this, we decided to use AI technology and computer vision to transfer Yangliuqing New Year prints to the Pop art style. First of all, the transfer of image style is a new application direction for Yangliuqing New Year prints. This is a new attempt and expansion for New Year prints, a cultural heritage, and will have a certain positive impact on publicity and promotion. Second, like other cultural heritage, the style transfer of images is very attractive to tourists and can improve user experience to some extent [32].

In the early stage of the experiment, the researchers used two AI products, “dream” and “night café”, that are currently popular on the Internet, and Vgg-19 for the pop art style transfer, but the result is unsatisfactory, as shown in Figure 3.

Figure 3. From left to right: original Yangliuqing New Year prints image; generated by “night café”; generated by “dream”; and generated by Vgg-19.

Therefore, it is currently difficult to use the GANs model alone to generate a usable pop-art style image with good quality, and it will also make the program heavy and inconvenient to apply to different scenarios. Thus, the researchers plan to generate images through the following steps: First of all, the current New Year prints have low image

quality. Due to the age and improper preservation, the images are stained, blurred, and other factors that are not conducive to use. Therefore, it is necessary to use a GANs to repair the image first, so that the image becomes smooth and clear. Secondly, combined with the artistic characteristics of pop art images, we can find that most pop art images are composed of two layers; one is the foreground graphics and the other is the background (Figure 4). Then, we need to binarize the generated image to separate the New Year picture content from the background. Finally, the image is re-colored, by extracting the color of the Pop art style, the binarized image is colored with the Pop art color, and finally, an image with the Pop art style is generated. Among them, step 1 is image preprocessing, and step 2 and step 3 are image postprocessing. The processing flow is shown in Figure 5.

Figure 4. Pop art style image.

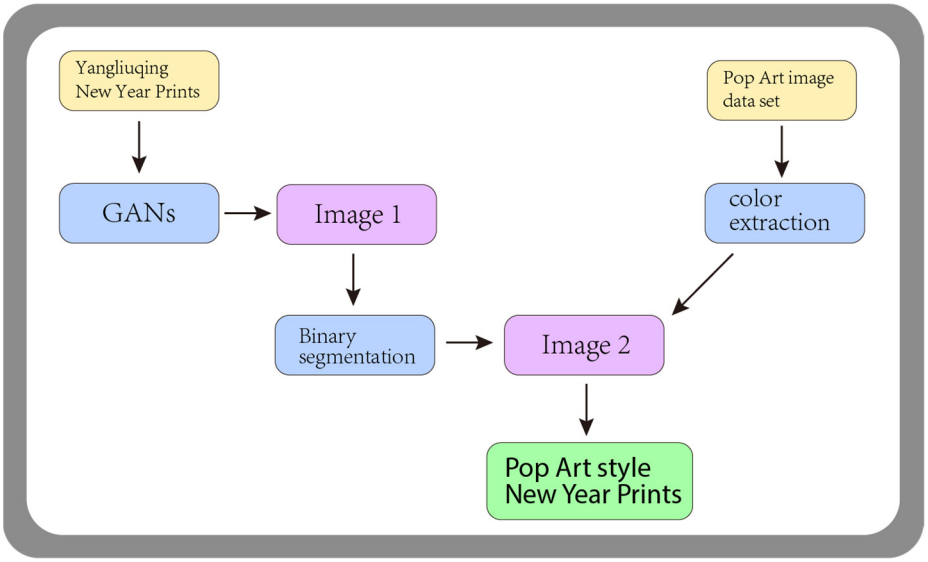

Figure 5. Processing flow.

3.1. Data Introduction and Preprocessing

AnimeGAN proposed by Chen et al. in 2020 is a lightweight application [33]. It is a network composed of neural style transfer and a generative confrontation network. It is

trained by a large number of comic-style datasets, with four pre-trained model weights: celba_distill.pt, face_paint_512_v1.pt, face_paint_512_v2.pt, and paprika. pt.

The network structure of the generator and discriminator is shown in Figure 6. In the generator, the number on the boxes is the number of channels, SUM means the element-wise sum, and IRB represents the reverse residual block. In the discriminator, K represents the size of the convolution kernel, S represents the stride in each convolutional layer, C represents the number of the feature maps, and Inst_Norm is the instance normalization layer. To effectively reduce the number of parameters of the generator, 8 consecutive and identical IRBs (inverted residual blocks) are used in the AnimeGAN network. In the generator, the last convolutional layer with a 1×1 kernel uses a normalization layer, followed by a tanh non-linear activation function. The model mainly solves the problem of high-frequency artifacts in the images generated by the model. Layer normalization can make different channels in the feature map have the same feature attribute distribution, which can effectively prevent the generation of local noise.

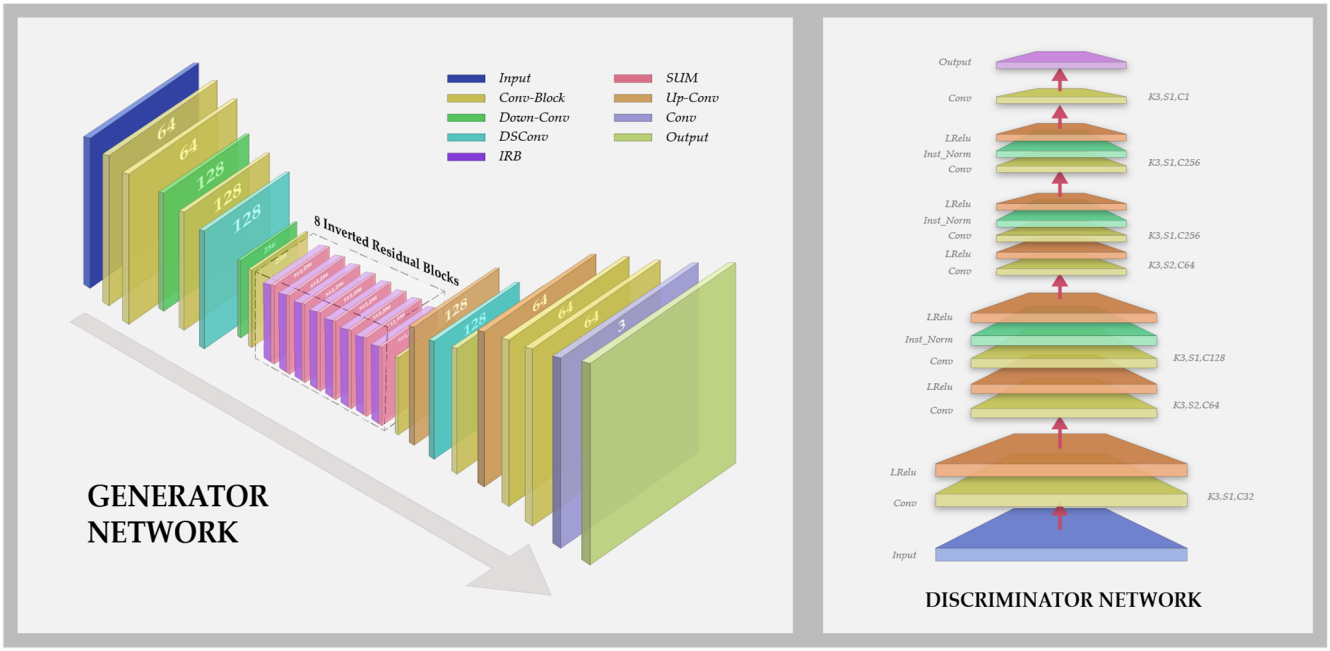

Figure 6. Model's architecture.

In the GANs model, to further improve the visual effect of generated images, three simple but effective loss functions are used, grayscale style loss, color reconstruction loss, and grayscale confrontation loss. The loss function L (G, D) can be simply expressed as follows:

$$L(G,D) = \omega_{adv}L_{adv}(G,D) + \omega_{con}L_{con}(G,D) + \omega_{gra}L_{gra}(G,D) + \omega_{col}L_{col}(G,D) \quad (1)$$

Among them, L_{adv} (G, D) is the adversarial loss that affects the animation transformation process in the generator G; L_{con} (G, D) is the content loss that helps the generated image retain the content of the input photo; and L_{gra} (G, D) represents the grayscale style loss.

In the generative network, the grayscale style loss and the color reconstruction loss make the generated images have sharper edges and more defined textures. A grayscale adversarial loss in the discriminator network makes the generated images have vibrant colors, and an edge-boosting adversarial loss is also used to preserve sharp edges. Therefore, by using this network, the clarity and edge information of New Year prints images are improved, and unimportant picture loss is repaired.

Input the image of Yangliuqing New Year prints into the model, and the image generated by using celba_distill.pt among the four pre-trained weights is more in line with

the purpose of this research. By adjusting the parameters, we can obtain the result as shown in Figure 7.

(**a**) (**b**)

Figure 7. (**a**) is the original Yangliuqing New Year print; while (**b**) is the processed image.

3.2. Image Postprocessing

Based on the Pop art style image form, the binary segmentation of the image can be performed by calculating the average gray level of the whole image. In this way, the foreground and background of the characters in the processed New Year prints images can be separated in batches and automatically. First, divide the image into small blocks, calculate the histogram of each block separately, and calculate its threshold for each block according to the peak value of each histogram. Then, the threshold of each pixel is obtained by interpolation according to the threshold of adjacent blocks.

The process is roughly to calculate a moving average by iterating through the images. If a pixel is significantly lower than this average, it is set to black, otherwise, it is set to white. Suppose P_n is the pixel at point n in the image. At this moment, we assume that the image is a single row of pixels connected by all pixels, as shown in Figure 8.

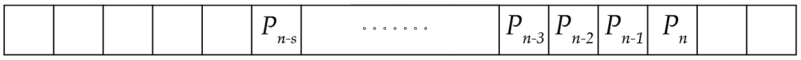

Figure 8. Assuming the pixels of the image line up in a row.

Suppose $f_s(n)$ is the sum of the last s pixels at point n:

$$f_s(n) = \sum_{i=0}^{s-1} p_{n-i} \tag{2}$$

The final image $T(n)$ is 1 (black) or 0 (white) depending on whether it is darker than t percent of the average of its previous s pixels.

$$T(N) = 1 \text{ if } p_n < \left(\frac{f_s(n)}{s}\right)\left(\frac{100-t}{100}\right) \text{ or } T(N) = 0 \text{ otherwise} \tag{3}$$

By experimenting, using 1/8 of the width of the image for s, and a value of 15 for t can produce better results for different images. The final binary segmentation is shown in Figure 9:

Figure 9. This is a figure. Schemes follow the same formatting.

Next, we need to colorize the image based on binary segmentation. Here, it is necessary to cluster and classify pop art data colors by means of pattern recognition techniques. Clustering is the process of looping together similar things and separating data into distinct groups based on the similarity of features [34,35]. The k-means algorithm is a prominent clustering method applied to pop art color extraction. k-means clustering is a method of vector quantization, originally from signal processing, that aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean (cluster centers or cluster centroid), serving as a prototype of the cluster. The data set can be classified, which belongs to unsupervised learning. The color is then extracted from the images in the obtained common Pop art style image data set (as shown in Figure 10) using the K-MEANS clustering algorithm.

Figure 10. Part of the Pop art style image data set.

For the sample set $D = \{X_1, X_2, \ldots ., X_m\}$. The K-Means algorithm is to minimize the square error for the clustering division $C = \{C_1, C_2, \ldots \ldots , C_k\}$:

$$E = \sum_{i=1}^{k} \sum_{x \in C_i} |x - u_i|_2^2 \tag{4}$$

Among them:

$$u_i = \frac{1}{|C_i|} \sum_{x \in C_i} x \tag{5}$$

is the mean vector of cluster C_i. It can be seen from the above formula that this formula describes the closeness of the samples in the cluster around the cluster mean vector, and the smaller the E value, the higher the similarity of the samples in the cluster.

Its processing process is shown in Figure 11.

1. Randomly select k points as the initial cluster center;
2. For the remaining points, according to their distance from the cluster center, they are classified into the nearest cluster;

3. For each cluster, calculate the mean of all points as the new cluster center;
4. Repeat 2 and 3 until the cluster center no longer changes.

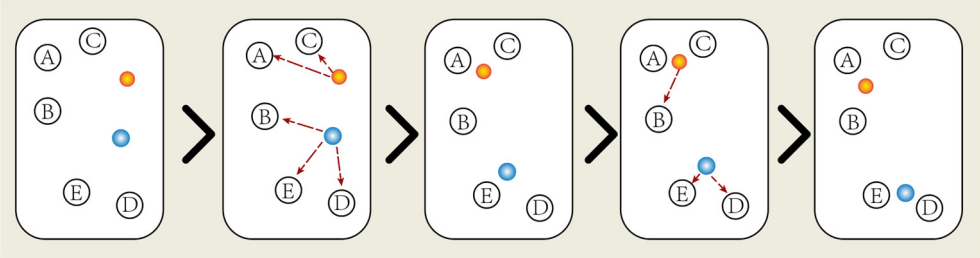

Figure 11. K-means clustering algorithm process.

The elbow method is a method that determines the ideal number of clusters by analyzing the fraction of clusters that form an elbow at a given location [36]. When the K value is smaller than the real K, the cost value will be greatly reduced every time K increases by 1. When the K value is greater than the real K, the cost value will not change so obviously when K increases by 1. In this way, the correct K value will be at this turning point, similar to the elbow. The elbow method calculation formula is:

$$D_k = \sum_{i=1}^{K} \sum \text{dis t}(x, c_i)^2 \tag{6}$$

Therefore, in this study, the elbow method is used to determine the K value, and it can be found that the optimal number of clusters is 3, as shown in Figure 12.

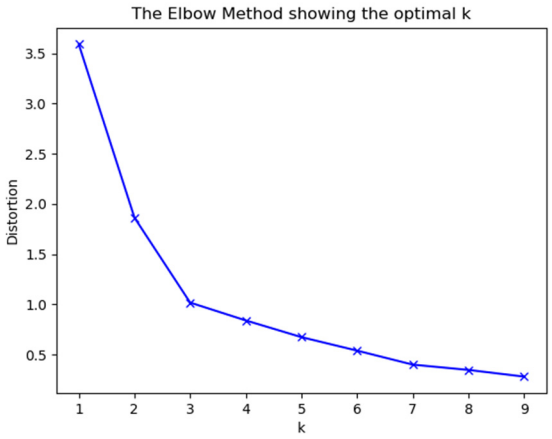

Figure 12. Optimal cluster number of elbow method.

In the python code, we set K = 3. The total result is shown in Table 2. The center point is calculated by the program, and each point is composed of 3 points, corresponding to RGB channels.

Table 2. Value of RGB channels.

R	G	B
15	66	95
254	59	127
246	234	31

We visualize the data, and finally obtain the color classification in Figure 13.

Figure 13. Color after visualization.

The Pop art style color extracted above is assigned to two different connected domains (foreground and background) separated by binarization. The resulting Yangliuqing New Year prints image has a distinct Pop art style. Shown in Figure 14.

Figure 14. This is a figure. Schemes follow the same formatting.

4. Cultural and Creative Product Development and Analysis

The concept of cultural creativity first appeared in the UK, which means the combination of creativity, culture, and knowledge. According to the British Ministry of Culture, Media, and Education, the term "cultural and creative industries" refers to businesses that draw on people's creativity, skills, and talents and have the potential to generate income and employment through the creation and exploitation of intellectual property rights [37]. The research team of Beijing Academy of Social Sciences "Research on the Development of Beijing Cultural and Creative Industries" made a clear statement in "The Development Orientation of Beijing Cultural and Creative Industries". With creation, creativity, and innovation as the fundamental means, cultural content and creative achievements as the core value, and the realization or consumption of intellectual property rights as the transaction characteristics, it is an internally connected industry cluster that provides a cultural experience for the public [38]. Zhang proposed a new definition after analyzing China's "cultural industry", "creative industry" and "cultural entrepreneurial industry": "Cultural and creative industries are based on cultural industries, with agriculture, industry and the tertiary industry as creative objects, with entrepreneurial planning as the core, and using new media technologies such as design, planning, software, network, and computer services. Through the industrial chain formed by the manufacturing and marketing of products and the development of derivatives, cultural products, and cultural services are transformed into a value chain of goods and services, and an emerging industry that finally realizes the diffusion and value-added of the value" [39].

The most important content in the cultural and creative industry is cultural and creative products. UNESCO defines cultural and creative products as: "consumed by the creativity of individuals or groups to convey meaning, symbols, and lifestyles. Including printed publications, music, photography, commercial design, environmental art, film and television, and game products" [40]. The UK Department of Culture, Media and Sport

defines it as "any product or combination of products produced by the cultural and creative industries" [37]. The cultural and creative products of cultural heritage are essentially an extension of cultural heritage, and their purpose is to convey the history, knowledge, culture, and aesthetics of cultural heritage.

On the design and development of cultural and creative products, scholars have conducted discussions from various disciplines. Through the analysis of cultural and creative products from the Palace Museum, Aixin et al. present fresh concepts for the development of local cultural and creative heritage, filling in the gaps left by "weak" cultural heritage forms with "strong" cultural and creative products [41]. Zhang et al. summed up a variety of development models, including cooperation with manufacturers, open market procurement, art licensing, and licensing also includes direct licensing, entrusted licensing, and comprehensive licensing [42]. Yi placed cultural heritage and creative products in the context of consumption, and also put forward design principles such as "making the best use of the situation, cultural creativity, people need, and brand synergy" from an economic perspective [43].

Consumer behavior research is also the core issue in the research of cultural and creative products. In 2018, based on rational behavior theory and satisfaction theory, Guo Meini analyzed the influence of the perceived value of cultural and creative products on user satisfaction and purchase intention. Through a long-term questionnaire survey, empirical analysis is carried out. It is concluded that consumer purchase behavior intention is mainly affected by user satisfaction and perceived purchase cost, and satisfaction is mainly affected by perceived culture, and it is proposed that in the process of cultural and creative product development, by improving the expressiveness of cultural and creative elements of products, consumer satisfaction can be improved, thereby affecting consumers' consumption intentions [44].

Based on the theory of planned behavior, Shi et al. conducted an empirical analysis of the willingness to consume cultural and creative products of Qiang embroidery clothing, put forward multiple hypotheses, and constructed a satisfaction model of consumption willingness of cultural and creative products of Qiang embroidery clothing under the label of intangible cultural heritage (Figure 15). The analysis results prove that the consumption willingness model of cultural and creative products from the perspective of intangible cultural heritage labels is established and confirms that consumers are willing to pay for cultural and creative products of cultural heritage with perceived cultural, perceived quality, and perceived usefulness. The reason is that cultural and creative products are essentially spiritual consumer goods, and consumers buy them because of the cultural value of cultural heritage. At the same time, Shi et al. proposed, based on the research conclusions, that the dissemination and publicity of cultural heritage should be strengthened, covering multiple channels, meeting the needs of different people, and enhancing the emotional identity of cultural heritage. In the design and development of cultural and creative products, enhance creativity and match the various needs of current main consumers [45].

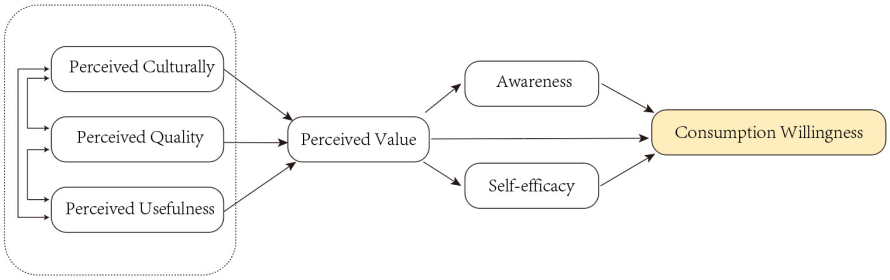

Figure 15. Consumption willingness model of Qiang embroidery cultural and creative products under the label of intangible cultural heritage.

Qian conducted an empirical study in 2018 to explore the relationship between contemporary college students' evaluation attitudes toward cultural and creative products and

their purchase motivation. He investigated three core cities in China and collected a total of 7661 valid data [46]. Analyze the internal relationship between evaluation and purchase behavior in seven aspects: comprehensive creativity, design, production technology, regional characteristics, collection value, function, and cost performance. It is concluded that: First, cultural and creative products are a special category of commodities. Although college students have a high pursuit of cultural aesthetics, "cost performance" has the largest proportion in making the final purchase decision. Second, some scholars believe that cultural and creative products do not lie in commercial benefits, but in the establishment of their cultural symbols and the dissemination of cultural value [47]. However, the dissemination of culture must be based on the acceptance of consumers. Therefore, meeting the real needs of consumers is the basic link of whether cultural and creative products can satisfy the dissemination of cultural symbols and cultural values.

Wang in her dissertation conducted qualitative and empirical research based on the theory of planned behavior, the technology acceptance model, and the user value acceptance model. It is proposed that cultural and creative products are paid attention to by the public in five aspects: interest, culture, quality, aesthetics, and personality. In her empirical research, she found that the cultural and creative consumer groups are dominated by women, accounting for 76%. People under the age of 30 accounted for 89.7% of the main consumer groups, 63.8% of consumers had a bachelor's degree, and 61.4% were school students. In the types of cultural and creative product purchases, the options are multiple-choice questions, so the percentage exceeds 100%. Among them, the first three items are accessories, accounting for 75.6%, clothing and luggage 42.1%, and daily necessities 41.8%. Among the purchase channels, purchases from online stores accounted for 72% [48]. In general, we should pay attention to product design and innovation, dig out our cultural resources, and create products with distinctive features and styles, which will attract consumers more easily.

The Beijing Palace Museum opened the online store "Palace Taobao" in 2008. Through the development of text, images, and historical stories, as well as bold innovations in product types and styles, the Palace Taobao has become the most popular online store for cultural and creative products, and many products have become online celebrity products (Figure 16). Up to now, the Palace Museum has developed nearly 10,000 kinds of cultural and creative products, and the annual sales of cultural and creative products in 2018 exceeded 1.5 billion yuan.

Figure 16. Palace Taobao.

The author sorts the products with the most sales in the product categories of the Forbidden City Taobao store, selects the products with the highest sales, and combines them with the Pop art-style New Year paintings generated by AI in the previous section to design and develop cultural and creative products. As the accessories category accounts for the highest proportion, two products are selected. As of October 2022, the highest sales

of accessories are mobile phone cases and key chains, T-shirts for clothing and luggage, and desk calendars for daily necessities. The final product is shown in Figure 17.

Figure 17. Cultural and creative products designed and developed by researchers: (**a**) keychain, (**b**) T-shirt, (**c**) desk calendar, and (**d**) phone case.

After completing the product design, we need to evaluate these cultural and creative products. At the same time, it is necessary to determine whether it can stimulate the interest and attention of young people to make a purchase. In 2018, Qi et al. built an index system for the evaluation of cultural and creative product design results through a combination of qualitative and quantitative methods and verified the effectiveness of the evaluation index system constructed through empirical research. The five-level Likert scale data analysis leads to the conclusion that the more points cultural and creative products receive, the more popular they are. Additionally, it is put to the test against already available creative and cultural products, and it is found that the better the score, the better the sales [49].

This paper refers to the evaluation model and questionnaire content of Qi et al. and eliminates and modifies the content of the questionnaire that has nothing to do with this article. We summarize four types of influencing factors and 9 evaluation indices, as shown in Table 3.

Table 3. The 4 influencing factors, 9 evaluation indices, and their interpretations.

Influencing Factors	Evaluation Indices	Index Interpretation
Cultural factors	Regionality	Products can directly or indirectly reflect the regional culture of New Year prints
	Emotion	The product has the cultural story of New Year pictures, which can meet the spiritual and emotional needs of users
Innovation factor	Attraction	The product is novel, attractive, and unique
	Innovation	Products conform to modern aesthetic concepts and lifestyles, with innovative design concepts and novel forms of expression
	Commercial value	Product positioning is clear and has market prospects
Experience factor	Use experience	Product features are clear and easy to use
	Aesthetic experience	The product conforms to contemporary aesthetics and can bring aesthetic enjoyment to users
Design expression factor	Modeling	Harmonious collocation of shape, color, pattern, material, etc.
	Structure	Simple structure, easy to implement

A total of 200 Likert 5-level questionnaires were distributed and 195 valid questionnaires were distributed to young people (age < 30) for the four New Year pictures cultural and creative products mentioned above, with an added purchase intention question at the end. The evaluation scores of the final four products are shown in Table 4 the total score is related to four factors, and the purchase intention is calculated separately.

Table 4. Four products scores.

Products	Phone Case	Keychain	Desk Calendar	T-Shirt
total score	4.137375	3.91965	3.823425	3.52935
Cultural factors	3.8001	3.5941	4.1428	3.9176
Innovation factor	4.5799	4.1150	3.9174	3.3837
Experience factor	3.9189	3.8350	3.4051	3.0220
Design expression factor	4.2506	4.1345	3.8284	3.7941
Purchase Intention	4.1666	3.9821	3.8106	3.1372

It can be seen from the scores that phone cases are the most popular among young people, with a total score of 4.137375, and keychains with a score of 3.91965. Both scores are above 3.9, indicating that portable cultural and creative products are more popular among young consumers. The score of T-shirts is 3.52935, ranking the lowest among cultural and creative products. The survey on purchase intentions is only 3.1372, indicating that consumers' willingness to purchase T-shirts is relatively weak.

According to interviews with two randomly selected samples who filled out the questionnaire, for clothing products, they pay more attention to clothing materials, styles, and functionality, followed by aesthetic elements such as printing and culture. Therefore, the willingness to purchase will be weaker than other cultural and creative products. As for the other three products, they all expressed great interest, and they also liked the New Year prints in pop art style, which felt very fashionable, fun, and interesting. Based on the higher scores of the first three cultural and creative products, we can know that the Pop art style New Year prints cultural and creative products generated based on AI are popular among young consumer groups, consumers are highly purchase-willing and have high user satisfaction.

5. Discussion and Conclusions

In our paper, the combination of Chinese New Year prints and AI technology generates new forms of artistic expression, which broadens the product categories of New Year prints and increases their diversity, and the results are also positive. Through questionnaire surveys, AI-generated Pop Art-style images have attracted the attention and love of young people. This is a meaningful attempt for New Year prints and even other traditional cultural heritage. Through the analysis of the background, we can clearly understand the current problems of Chinese New Year prints, although the government and scholars have protected the New Year prints culture. However, in the long run, this can only ensure that these cultures will not disappear in the progress of the times. We not only need to protect these cultural heritages, but also aim so that these excellent traditional cultural heritages can return to the public's sight in the current information age, instead of being kept in museums. Therefore, we not only need to use new technologies and new means to better protect cultural heritage, but also need to develop new applications to allow more people to participate and arouse the love of the public, so that they are willing to learn about traditional culture.

Formally for this purpose, the author introduces the recent popular AI-generated art into New Year prints and generates high-quality Pop art-style New Year prints through the application of GAN model generation and image post-processing. These images are further applied to cultural and creative products of New Year prints to increase the form of expression. This work not only provides a new research direction for Chinese New Year prints, but also provides references for other different cultural heritages. However, traditional cultural heritage still requires human factors to participate in the development, especially the creation of New Year prints that rely on cultural inheritors. There is no doubt that AI cannot replace the role and status of inheritors in New Year prints culture. In this study, AI-generated New Year prints can expand the users of New Year prints in the current era, attract more people's attention, expand the types of New Year prints, increase the income of related practitioners, and form a virtuous circle.

In conclusion, we innovatively propose a new combination of GANs and computer vision for image post-processing, so that the generated Yangliuqing New Year prints have a high-quality pop art style. The generated artistic images are used in the development of cultural and creative products of Yangliuqing New Year prints, which has received good feedback from young people and provides a new way for the promotion of New Year prints. At the same time, the well-tuned model is not affected by the factors of the graphic designer. Young people can choose their favorite Yangliuqing New Year prints to generate, increasing user interaction and enhancing user experience. Previous papers based on artificial intelligence style transfer have little research on the practical application of cultural heritage. This paper fills this gap and proposes a project that applies the generated images to cultural heritage and provides a new idea for the current development dilemma of Chinese New Year prints. Nevertheless, there are some limitations to this article. For instance, the GAN network is better suited to processing New Year prints of characters; however, it will lose image details when processing large scenes, and there are not many samples available for evaluating cultural and creative products. Due to limited space, the copyright issue of AI-generated art also needs detailed discussion and in-depth research.

In future research, the researchers will further study the application of the combination of AI deep learning technology and New Year prints. Although digital technology cannot replace cultural heritage, it can better protect and disseminate cultural heritage. Next, the researchers will explore in depth from the following directions: 1. Create a labeled data set for Yangliuqing New Year prints for AI training. Although the current New Year prints are preserved digitally, they are all in basic digital image storage. With the creation and labeling of the New Year prints data set, it is now possible to train AI at a higher level and utilize it for completing assignments like restoring damaged New Year prints and retrieving their images. 2. GANs trained on the New Year prints data set can transfer the provided portrait photo trans to the style of the New Year prints characters. It can be packaged

into APP applications such as TikTok and other high-usage applications to inspire more people to use it. It is beneficial to the dissemination of New Year prints so that more people can understand the cultural heritage of New Year prints. 3. AI can be trained through the New Year picture data set, and interactive applications can be developed to allow users to participate in the creation of New Year pictures. For example, the corresponding New Year prints scene is generated based on the user's simple stick figure. These can be applied to scenes such as the New Year Prints Museum for visitors to interact and enhance user experience.

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