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# Research on AI Image Generation Technology-Based Comic IP Image Character Design of Agricultural and Side Products in Jilin Province to Help Rural Revitalization

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**Abstract** Agricultural and sideline products in Jilin Province lack distinctive image identity, AI image generation technology provides a new way to create distinctive comic IP characters, which helps to enhance brand value and promote rural revitalization. In this study, we constructed an intelligent image generation model of Multi-shape Generative Adversarial Network (MW-GAN), which contains two parts: style network and geometric shape network, and ensures that the features of agricultural and sideline products are retained through techniques such as identity preserving loss design. The experiment uses a homemade agricultural and by-products caricature dataset (AVPDS), which contains a total of 2,165,496 images of 3,214 agricultural and by-products from 10 angles in Jilin Province. The evaluation results show that the IS index value of the model reaches 94.91, which improves from 7.46% to 41.03% compared with the comparison method; the FID index value is 6.63, which reduces from 6.88% to 26.59% compared with the comparison method. In extreme postures (75° and 90°), the recognition rates reached 85.45% and 77.83%, respectively. The user survey showed that the agricultural and sideline products cartoon IP image value score was 4.319, the brand association score was 4.162, and the brand identity score was 4.285, and the regression analysis confirmed that all three factors had a significant positive impact on rural revitalization. The results of the study show that the design of agricultural and sideline products cartoon IP image based on AI technology can effectively disseminate brand culture, enhance product recognition, and promote the development of rural revitalization.

**Index Terms** AI image generation technology, agricultural and sideline products, caricature IP image, polymorphic generative adversarial network, brand identity, rural revitalization

## I. Introduction

As an important national grain base, Jilin Province in China has made many efforts in the construction of agricultural and sideline products, and landmark products such as Changbai Mountain ginseng and Meihuashu deer have gained a relatively objective market share. In addition, a number of green, organic and pollution-free agricultural and sideline product bases have been constructed, and the number of “three products and one standard” certified agricultural products in the province has been rising year by year. On this basis, Jilin Province in agricultural and sideline product production, labeling and certification, specifications and packaging, brand publicity and other aspects of standardization as a leader, has made substantial improvements and breakthroughs, and fostered a number of high-quality agricultural and sideline product brands with regional characteristics [1], [2]. Under the impetus of agricultural standardization, with the improvement of product quality and the implementation of famous brand strategy, the market development ability of agricultural and sideline products in Jilin Province has been continuously enhanced, which has increased the income of farmers and promoted the development of rural revitalization [3].

While fully affirming the achievements of brand building of agricultural and sideline products in Jilin Province, it should also be soberly recognized that there are still problems in its development that need to be improved. Although the number of brand building is large, the brand conversion rate is low, the brand premium ability is low, the agricultural and sideline products are difficult to sustain the development, and for the reason of cost and regional characteristics, the packaging design of agricultural and sideline products has become a hard-hit area of product homogenization, which reduces the customer's purchase rate [4], [5]. Therefore, by creating unique and attractive comic IP image characters is an effective solution that has been applied to several consumer industries. To create a high-quality and unique IP character display experience for fans and consumers, to satisfy consumers' love and expectation of the character, to stimulate consumers' purchase impulse, to increase product sales in the market,

and thus to strengthen their sense of identity and loyalty to the IP brand [6]. And to create IP character display content with topicality and spreading power, encourage the audience to spontaneously share in social media and other platforms, expand the influence and spread of IP, so as to attract a large number of brands and enterprises to seek cooperation and authorization [7].

With the continuous progress of science and technology, the application of artificial intelligence in various fields is becoming more and more extensive, in which AI image generation technology is an important part of the application of artificial intelligence, this kind of generative AI technology can efficiently generate design drafts, integrate a variety of artistic styles, extract image features, realize style transfer, build interactive platforms, personalized content generation, etc., which provides a boost to create IP [8]-[12].

Agricultural and sideline products, as an important part of rural economic development, face the challenge of brand building and image shaping. With the arrival of the digital era, consumers pay more and more attention to the emotional resonance and cultural connotation of the products, and the cartoon IP image, as a carrier to show the brand's personality and culture, has become an effective means of product promotion and brand building. This study focuses on the character design of caricature IP image of agricultural and sideline products in Jilin Province, and proposes an AI image generation model based on Multi-Wave Generative Adversarial Network (MW-GAN), which aims to caricature agricultural and sideline products featured in Jilin Province and create an IP image with distinctive regional characteristics and brand tone. The model consists of a style network and a geometric morphing network, and through the techniques of key point detection, style transformation and identity preservation, it ensures that the generated caricature IP image retains the original features of the agricultural and sideline products, as well as the artistic expressiveness and recognizability. The study not only focuses on technical innovation, but also explores the influence mechanism of cartoon IP image value, brand association and brand identity on rural revitalization through user surveys and regression analyses, providing new ideas for the cultural communication of the “Jilin, authentic delicious” brand. This study combines AI technology with agricultural and sideline product branding, which not only reflects technological innovation, but also provides a practical solution for rural revitalization.

## II. Intelligent image generation model for polymorphic generative adversarial networks

The core of the research work in this paper is the generation of IP image characters for agricultural and sideline products cartoons, and the AI image generation technology [13] is used to construct a Multi-shape Variation Generative Adversarial Network Image Generation (MW-GAN) model, which is based on the Generative Adversarial Network model [14], [15], and focuses on the geometrical variation diversity problem in the process of generating agricultural and sideline products cartoon IP characters.

The symbols $x$, $z$, $l$, and $y$ are used to denote images, cryptic coding, key points of agricultural products, and identity category markers, respectively. The subscripts $p$ and $c$ in the notation denote photographs and cartoons, respectively, and the superscripts $s$, $c$, and $l$ denote color styles, content, and agri-product keypoints, respectively. The encoder, generator, and discriminator in the model are then denoted by the symbols $E$, $G$, and $D$, respectively.

The model structure of the polymorphic generative adversarial network is shown in Fig. 1, where the left part of the figure shows the style network and the right part shows the morphology network. The black solid line with arrows indicates two self-encoders, where the upper one is for the photo image and the lower one indicates the reconstruction process for the manga image. The orange dashed line with arrows indicates the transformation process from photo to comic, while the blue dashed line with arrows indicates the transformation process from comic to photo.

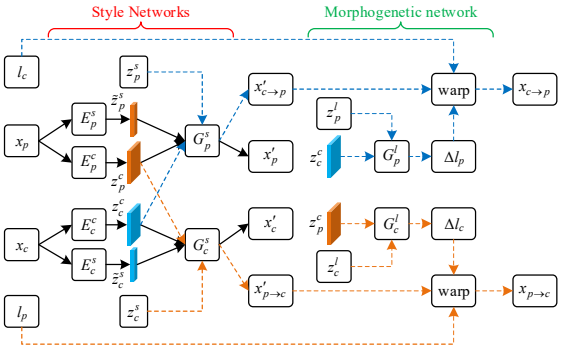


Figure 1: Multi-deformation generation against network structure

### *II. A.Comic style web design*

The image reconstruction process is shown as the black solid line with arrows in Fig. 1, and the conversion process can be expressed by the following equation:

$$x'_p = G_p^s(E_p^c(x_p), E_p^s(x_p)) \tag{1}$$

$$x'_c = G_c^s(E_c^c(x_c), E_c^s(x_c)) \tag{2}$$

where $E_p^c$ and $E_p^s$ are the content and style encoders of the photo image and similarly, $E_c^c$ and $E_c^s$ are the content and style encoders of the manga image respectively. The $G_p^s$ and $G_c^s$ are then the generators for the photo style image and the comic style image, respectively. Here the reconstruction loss of the image is defined as the $l_1$ paradigm between the input image and the output image:

$$L_{rec\_x} = \left\| x'_p - x_p \right\|_1 + \left\| x'_c - x_c \right\|_1 \tag{3}$$

The image style conversion process is shown as the dotted line with arrow in the style network section in Fig. 1, and this process can be represented by the following equation:

$$x'_{p\to c} = G_c^s(E_p^c(x_p), z_c^s) \tag{4}$$

$$x'_{c\to p} = G_p^s(E_c^c(x_c), z_p^s) \tag{5}$$

where $z_c^s$ and $z_p^s$ are the style codes of the cartoon and the photo sampled from a Gaussian distribution, respectively. $x'_{p\to c}$ is the image after transforming the input photo into the comic style, and $x'_{c\to p}$ is the image after transforming the input comic into the photo style.

The constraints in the image style conversion process include three main aspects. Firstly, the style code of the converted image should be the same as the input style code when the image is generated if the style code is extracted again by the corresponding encoder, so the following style code reconstruction loss can be obtained:

$$L_{rec\_s} = \left\| z_p^s - E_p^s\left(x'_{c\to p}\right) \right\|_1 + \left\| z_c^s - E_c^s\left(x'_{p\to c}\right) \right\|_1 \tag{6}$$

Secondly, the content encoding of the image should be consistent during the style transformation process, so the model can be trained by the cyclic consistency loss of content encoding, which is defined as follows:

$$L_{cyc\_c} = \left\| E_p^c\left(x_p\right) - E_c^c\left(x'_{p\to c}\right) \right\|_1 + \left\| E_c^c\left(x_c\right) - E_p^c\left(x'_{c\to p}\right) \right\|_1 \tag{7}$$

Finally, when using the style encoding of the original input image as the input to the style encoding to invert the transformed image, the model should be able to reconstruct the original input image. Thus there is the following image loop consistency loss:

$$\begin{aligned} L_{cyc\_x} = &\left\| x_p - G_p^s\left(E_c^c\left(x'_{p\to c}\right), E_p^s\left(x_p\right)\right) \right\|_1 \\ &+ \left\| x_c - G_c^s\left(E_p^c\left(x'_{c\to p}\right), E_c^s\left(x_c\right)\right) \right\|_1 \end{aligned} \tag{8}$$

With this stylistic network structure design, the model is able to generate IP image images of agri-food cartoons with different texture styles by sampling different stylistic codes.

### *II. B.Geometric deformation network design*

Based on the above assumptions, the deformation network of MWGAN consists of two generators $G_c^l$, $G_p^l$ and two encoders $E_p^l$, $E_c^l$. Where the generator $G_c^l\left(G_p^l\right)$ is used to learn the first mapping relation, i.e., it receives the content encoding $z_p^c\left(z_c^c\right)$ and the keypoint transformation encoding $z_c^l\left(z_p^l\right)$ as inputs and generates the keypoint change volume $\Delta l_c\left(\Delta l_p\right)$, a process which can be represented by the following equation:

$$\Delta l_c = G_c^l\left(z_p^c, z_c^l\right) \tag{9}$$

$$\Delta l_p = G_p^l\left(z_c^c, z_p^l\right) \tag{10}$$

And the encoder $E_p^l\left(E_c^l\right)$ is used to learn the second mapping relation, i.e., it accepts the photo-comic keypoint pair $\left(l_p, l_c\right)$ (comic photo keypoint pair $\left(l_c, l_p\right)$) as an input and outputs the corresponding keypoint transformation code $\tilde{z}_p^l\left(\tilde{z}_c^l\right)$. This process can be represented by the following equation:

$$\tilde{z}_p^l = E_p^l(l_p, l_c) \tag{11}$$

$$\tilde{z}_c^l = E_c^l(l_c, l_p) \tag{12}$$

In order to train the deformation network, the first reconstructed keypoint transformation encoding should be consistent with the input, i.e:

$$L_{rec\_l} = \left\| z_p^l - E_p^l\left(\tilde{l}_p, l_c\right)\right\|_1 + \left\| z_c^l - E_c^l\left(\tilde{l}_c, l_p\right)\right\|_1 \tag{13}$$

The first term in Eq. is the reconstruction loss of the keypoint transformation encoding $z_c^l$ from photo to cartoon conversion and similarly the second term is the reconstruction loss of the keypoint transformation encoding $z_p^l$ from cartoon to photo conversion.

In addition to this, this research work also trains the model by LSGAN loss so that the generated keypoints of agricultural by-products are consistent with the real ones:

$$L_{gan\_l}^G = \left\|1 - D_p^l\left(\tilde{l}_p\right)\right\|^2 + \left\|1 - D_c^l\left(\tilde{l}_c\right)\right\|^2 \tag{14}$$

$$L_{gan\_l}^D = \left\|1 - D_p^l\left(l_p\right)\right\|^2 + \left\|D_p^l\left(\tilde{l}_p\right)\right\|^2 + \left\|1 - D_c^l\left(l_c\right)\right\|^2 + \left\|D_c^l\left(\tilde{l}_c\right)\right\|^2 \tag{15}$$

where $D_p^l$ and $D_c^l$ are the discriminators used to determine whether the photo keypoints and the cartoon key points are real, respectively.

### *II. C.Design for loss of identity retention*

Identity preservation in the IP generation of agro-cartoon is crucial, and two discriminators are added to the model structure for identity classification of the input data in the image space and the keypoint space, respectively, with the following loss functions:

$$\begin{aligned} L_{id\_x} = &-\log\left(D_{id}^x\left(y_p, x_p\right)\right) - \log\left(D_{id}^x\left(y_p, x_{p\to c}\right)\right) \\ &-\log\left(D_{id}^x\left(y_c, x_c\right)\right) - \log\left(D_{id}^x\left(y_c, x_{c\to p}\right)\right) \end{aligned} \tag{16}$$

$$\begin{aligned} L_{id\_l} = &-\log\left(D_{id}^l\left(y_p, l_p\right)\right) - \log\left(D_{id}^l\left(y_p, \tilde{l}_c\right)\right) \\ &-\log\left(D_{id}^l\left(y_c, l_c\right)\right) - \log\left(D_{id}^x\left(y_c, \tilde{l}_p\right)\right) \end{aligned} \tag{17}$$

Here, the two discriminators $D_{id}^x$ and $D_{id}^l$ are both agro-identity classifiers, with the difference that $D_{id}^x$ takes image data as input, while $D_{id}^l$ takes agro-identity keypoints as input. $y_p$ and $y_c$ are the identity labels corresponding to photos and cartoons, respectively.

### *II. D.Overall Loss and Model Training*

In summary, the training of polymorphic into adversarial networks is mainly achieved by optimizing the following loss functions: firstly, the reconstruction and cyclic consistency classes of losses, where the reconstruction class of losses includes the image reconstruction loss $L_{rec\_x}$, the style implicitly coded reconstruction loss $L_{rec\_s}$, and the key-point transition implicitly coded reconstruction loss $L_{rec\_l}$. The cyclic consistency loss includes the content coding cyclic consistency loss $L_{cyc\_c}$ and the image cyclic consistency loss $L_{cyc\_x}$. Then there is the generative adversarial loss, which specifically includes the generative adversarial loss $L_{gan\_x}^G$ and $L_{gan\_x}^D$ on images, the cyclic

consistency loss $L_{gan\_l}^{G}$ and $L_{gan\_l}^{D}$ on agro-products key-points, as well as the generative adversarial loss on cryptic coding $L_{gan\_z}^{G}$ and $L_{gan\_z}^{D}$. Finally, there is the identity preservation loss, which specifically includes identity preservation $L_{id\_x}$ on the image space and $L_{id\_l}$ on the keypoint space.

The whole model is trained on all the encoders, generators and discriminators by the following optimization:

$$\min_{E,G} \lambda_1 L_{rec\_x} + \lambda_2 \left( L_{rec\_s} + L_{rec\_z\_l} + L_{cyc\_c} + L_{cyc\_x} \right) + \lambda_3 L_{id\_x} + \lambda_4 L_{id\_l} + \lambda_5 \left( L_{gan\_x}^{G} + L_{gan\_l}^{G} + L_{gan\_z}^{G} \right) \tag{18}$$

$$\min_{D} \lambda_3 L_{id\_x} + \lambda_4 L_{id\_l} + \lambda_5 \left( L_{gan\_x}^{D} + L_{gan\_l}^{D} + L_{gan\_z}^{D} \right) \tag{19}$$

where $E$ and $G$ denote the encoder and generator networks, respectively, and $D$ denotes the discriminator network. The $\lambda_1$, $\lambda_2$, $\lambda_3$, $\lambda_4$, and $\lambda_5$ are hyper-parameters used to balance different loss weights. The entire model is trained together in a completely end-to-end manner. Specifically, for a set of training data the model alternately updates the parameters of $E$, $G$ and $D$.

## III. Experimentation and analysis of IP image generation for agricultural and sideline products cartoons

### *III. A. Self-production of data sets*

The agricultural and by-products caricature dataset (AVPDS) was captured using 10 Hikvision DS2CD3T56(D)WD 6mm cameras, which were collected independently by this laboratory. The dataset contains a total of 2,165,496 images of 3,214 agricultural and sideline products in Jilin Province from 10 angles for each individual under each angle, which is a huge amount of data.

The image size of AVPDS dataset is 1920×1080 pixels. In terms of data preprocessing, this paper first uses the key point detection method 3DDFA to detect the agricultural and sideline product regions and agricultural and sideline product key points in the whole image. Then the image is rotated and scaled by affine transformation, aligned by rotation and scaling, and finally cropped to 128×128 size.The AVPDS dataset contains a variety of lighting conditions such as morning, afternoon, and evening at the time of acquisition, and since this paper doesn't consider the effect of lighting on the frontalization for the time being, the whole dataset is preprocessed by using the bias detection based on image analysis and white balance algorithm of color correction, which reduces the impact of lighting on the frontalization. Because we do not consider the effect of illumination on frontalization in this paper, we also use the white balance algorithm based on image analysis for bias detection and color correction to preprocess the whole dataset, which reduces the effect of inconsistent illumination on frontalization results. In this paper, the images in the AVPDS dataset are divided into training set and test set according to the ratio of 8:2.

### *III. B. Experimental parameters and environment*

The experiment parameters are as follows:

Epoch is 200 generations, Batchsize is set to 32, Learning Rate is set to 0.0001, and Beta is set to 0.5. Meanwhile, Lambda_fate is set to 10.0, Dropout is 0.4, and Optimizer is chosen as Adam.

The experimental environment is as follows:

The model is based on PyTorch deep learning framework, the running environment of the experiment is Rocky Linux, the processor is Intel(R) Xeon(R) CPU E5-2660 v4, and the graphics card is two Tesla V100 32G GPUs.

### *III. C. Evaluation indicators*

The experiments use two evaluation metrics commonly used in the field of image generation, IS (Inception Score) and FID (Fréchet Inception Distance).

(1) IS

IS is a commonly used metric for evaluating the quality of image generation models, which measures the diversity and realism of the generated images.The idea of IS is to simplify the difficulty of the evaluation by mapping the evaluation problem of the generation model, to a classifier.The IS is calculated as Eq:

$$IS(G) = \exp\left( E_{x \sim p_g} D_{kl} \left( p(y|x) \| p(y) \right) \right) \tag{20}$$

where $G$ denotes the generator, $x \sim p_g$ denotes a set of images generated by the generative model, $y$ denotes the category of the images, $p(y|x)$ denotes the conditional probability distribution of the corresponding category

$y$ after the given image $x$, and $p(y)$ denotes the edge of the corresponding category $y$ for all images probability distribution.

A larger IS value indicates diversity and accuracy in the generated images, while a smaller IS value indicates a lack of diversity and accuracy in the generated images. However, it does not take into account the visual quality of the image, which sometimes leads to inconsistency between the evaluation results and human perception, since the classifier has the ability to distinguish between them even if a large amount of noise is present in the image. Therefore, other metrics, such as FID and human subjective evaluation, need to be taken into account when using IS for evaluation.

(2) FID

FID is also a metric used to evaluate the quality of generated images or videos. Its basic idea is to directly consider the distance between generated data and real data at the feature level, and no longer rely on additional classifiers. Its calculation formula is shown in Eq:

$$FID = \left|\mu_P - \mu_G\right|^2 + Tr\left(\Sigma_P + \Sigma_G - 2\left(\Sigma_P\Sigma_G\right)^{1/2}\right) \tag{21}$$

where $P$ denotes the distribution of the real image, $G$ denotes the distribution of the generated image, $\mu_P$ and $\mu_G$ denote the mean of the feature representations of the real and generated images, respectively, $\Sigma_P$ and $\Sigma_G$ denote the covariance matrices of the feature representations of the real and generated images, respectively, $Tr$ denotes the trace of the computational matrix, and $|*|$ denotes the Euclidean distance between two vectors.

The smaller the value of FID, the closer the distribution of the feature representations of the generated image and the real image, the higher the similarity between the generated image and the real image, and the higher the quality of the .generated image.

### *III. D. Image recognition rate and generation effect*

In order to more intuitively analyze the effectiveness of the above algorithm in generating the recognition performance of the IP image of the caricature of agricultural products. Frontalization is nested as a preprocessing in the existing recognition model to evaluate the recognition rate of agricultural and sideline products frontalization on a controlled dataset. The algorithms in this paper are compared with Light CNN, FNM, TP-GAN, PCCycle-GAN, PIM, and FM-GAN algorithms for the recognition of agricultural and sideline products positively on a homemade dataset.

The results of the comparison of the frontalized recognition rate of agricultural and sideline products are shown in Fig. 2. From the figure, it can be observed that this paper's algorithm obtains better results under all angles, proving its effectiveness in recognizing agricultural products. In addition, the recognition rate of both this paper's algorithm and the comparison algorithm decreases with the increase of the pose angle, this is because more surface information is lost with the increase of the pose angle thus making the cartoon IP synthesis task difficult to accomplish. As can be seen from the figure, the algorithm in this paper also shows high recognition performance at 75° and 90° in extreme pose. When the angle of face deflection posture is 75° and 90°, the recognition rate of this paper's algorithm reaches 85.45% and 77.83%, respectively. The reason is that this paper's algorithm further constrains the frontalization process by focusing on the important surface detail information of the agricultural products by combining the discriminator of the attention mechanism to enhance the local features of synthetic frontalization, and by using the identity loss to minimize the variability of the features in the depth space in order to maintain more identity features.

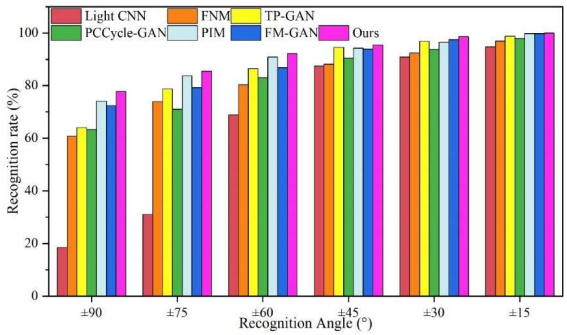


Figure 2: The positive recognition rate compares the results

In this section, this paper's algorithm is quantitatively compared with the above comparison methods, and the image generation IS metrics and FID metrics are used to evaluate the effectiveness of this paper's algorithm in generating the caricature IP image of agricultural and sideline products.

The results of quantitative evaluation of image generation of comic IP image are shown in Figure 3. As can be seen from the figure, the IS index and FID index values of this paper's algorithm are 94.91 and 6.63, respectively. the IS index value is improved compared with the comparison method, 7.46%~41.03%, and the FID index value is reduced compared with the comparison method, 6.88%~26.59%. Compared with other methods, this paper's algorithm performs the best in both FID index and IS index, which indicates that the IP image images of agricultural and sideline products cartoon generated by this paper's algorithm are more realistic and more in line with human perception.

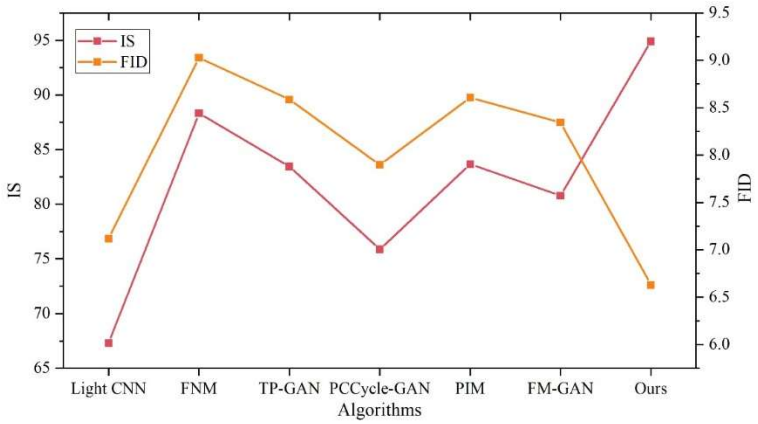


Figure 3: The image image generates quantitative evaluation results

## IV. Study on the Impact of Comic IP Image Character Design and Rural Revitalization

### *IV. A. IP image species selection*

This article mainly uses the method of "capturing brand positioning keywords" to complete the species selection for the IP. Based on the preliminary research on the brands of agricultural products in Jilin Province and the preferences of the target users, we selected animal images that reflect the brand tone of "honest, authentic, green, and safe" and align with consumers' demands for an IP image that is "cute, optimistic, warm, and friendly" for anthropomorphization.

### *IV. B. IP image style establishment*

The design style of IP image ranges from two-dimensional to three-dimensional, static to dynamic multi-functional design, combined with modern technology, materials for innovative production, can also be attached to the designer's own inspiration or creativity and according to the characteristics of the brand design, in order to highlight the brand's personalized features. The brand concept of Jilin agricultural and sideline products is to let consumers experience the brand culture of “generous Jilin, authentic delicious” as well as green, safe and authentic agricultural and sideline products of Jilin province. Therefore, in the design style positioning can not lack the Jilin culture elements and green, healthy, generous brand positioning elements. The IP image of Jilin agricultural and sideline products integrates traditional and modern elements, combines the brand characteristics and culture of Jilin agricultural and sideline products to create a 3D IP image, and the overall design style is popular with the “cute” element to create a cute and cuddly IP image that heals people's hearts, induces consumers' emotions, and stirs up spiritual understanding and cooperation. Considering the brand recognition and the accuracy of information dissemination, IP image design is generally based on the retention of species prototypes for artistic processing, combined with brand characteristics and culture to create a unique IP image, to strengthen the recognition and memory of the visual image.

### *IV. C. IP image color characteristics*

The color characteristics of the IP image should be more in line with the brand tone, concept and industry characteristics. There are four ways of color extraction are:

(1) Use the inherent color of the species, such as Deer Xiaojia.

(2) Using the brand color, such as Zhi Xiaobao.

(3) Decided by the brand story background, such as Doraemon.

(4) Decided by the target users.

The IP image design of the Jilin agricultural and sideline products brand uses ginseng and white deer as prototypes for IP anthropomorphization to meet consumer demand. The colors of the Jilin agricultural and sideline products brand LOGO are rich and varied, but a consistent brand color has not yet been formed. Therefore, in terms of color selection, the focus is placed on the animal's native color to simplify the IP image color identification in order to enhance consumer memory and cognition, and at the same time, it is also able to make a closer connection between the brand and the consumers.

### *IV. D. Impact of Comic IP Image on Rural Revitalization*

In order to verify the impact of the value of the agricultural and sideline products cartoon IP image designed in this paper based on AI image generation technology on rural revitalization, this section takes the previous maturity scale as the basis for designing the scale applicable to this study, measures the variables in the study, and designs the questionnaire.

By displaying the caricature IP image of agricultural and sideline products in this experiment, during this period the investigators were able to understand what the caricature IP image of agricultural and sideline products showed. After viewing the experimental materials, the value of the agricultural and sideline products comic IP image, brand association, and brand identity were scored separately, and the important variables in this study were measured in turn.

This study is based on research in five large public places offline, with the consumer population coming from different urban counties in Jilin Province, and randomly selected respondents from 23 urban counties in Jilin Province. A total of 617 questionnaires were recovered, and after data collection, the raw data were organized, and the questionnaires were deleted one by one by checking the time of filling in the questionnaires and the content of filling in the questionnaires. Finally, the screened questionnaires were tested or analyzed to ensure the quality of the survey data. There were 600 copies left, and the validity rate reached 97.24%. All items of the scale were measured using a 5-point Likert scale [16]: “Totally disagree” is 1 point. “Don't quite agree” is 2 points. “Unsure” was scored as 3. “Comparatively agree” was scored as 4. “Completely agree” is 5.

Table 1 shows the value, brand association, and brand identity scales of the IP image of agricultural and sideline products cartoons in Jilin Province. From the results in the table, it can be seen that the average rating of the investigators on the value of the IP image of agricultural and sideline products cartoon in Jilin province is between 4.097 and 4.493, with a composite score of 4.319.The average rating of the brand association of agricultural and sideline products is between 4.006 and 4.247, with a composite score of 4.162.The average rating of the brand identity is between 4.206 and 4.418, with a composite score of 4.285.The ratings of each dimension are higher than 4, indicating that this paper based on AI image generation technology can design a better IP image of agricultural and sideline products. dimension scores are all higher than 4, indicating that the agricultural and sideline products cartoon IP image designed based on AI image generation technology in this paper can better reflect the characteristics of agricultural and sideline products and is well liked by people.

Table 1: Image value, brand association, brand recognition scale

| Variable | Items | Mean | SD |
|---|---|---|---|
| Image value | Improve the efficiency of the solution of agricultural products | 4.372 | 1.008 |
| | The image of the cartoon IP is very attractive to me | 4.097 | 1.097 |
| | The IP image of the cartoon wants me to pass on the brand culture | 4.352 | 1.073 |
| | Ability to perceive value in the image of a cartoon | 4.279 | 1.369 |
| | The image of the cartoon is the value of the brand information transfer | 4.493 | 1.468 |
| Brand association | When seeing the image of the cartoon IP, it can be associated with the agricultural products | 4.247 | 1.056 |
| | When seeing the image of the cartoon IP, it can be associated with the form of the agricultural products | 4.006 | 1.421 |
| | The cartoon IP image can make people think of the scene that uses it | 4.234 | 1.293 |
| Brand identity | The image of the agricultural vice product is consistent with my aesthetic | 4.206 | 1.057 |
| | Satisfied with the image of agricultural products IP | 4.418 | 1.138 |
| | Identify the values expressed by the IP image of agricultural vice products | 4.232 | 1.442 |

Based on the above findings, it is hypothesized that agricultural and sideline product comic IP image value, brand association, and brand identity have a positive effect on rural revitalization. This subsection is further tested with

regression analysis, which is a statistical analysis method to determine the interdependence between two or more variables.

In this paper, multiple regression analysis will be used to test the hypotheses related to the model of factors influencing rural revitalization effects, and considering that demographic variables may play a disturbing role in the model, demographic variables will be used as control variables in the regression analysis. The regression results of rural revitalization effects are shown in Table 2. Model 1 in the table is the effect of control variables on the dependent variable rural revitalization effect, and Models 2 to 4 are the effects of adding the independent variables comic IP image value, brand association and brand identity on rural revitalization effect on the basis of control variables, respectively.

As can be seen from the data in the table, the model fit R-square of Model 1 for the dependent variable rural revitalization is 0.046, indicating that the explanatory rate of the control variables on the effect of rural revitalization is 4.6%, F=3.298, P<0.001, in which there is no significant effect of the control variables on rural revitalization. The R-squared change in the fit of model 2 for the dependent variable rural revitalization effect is 0.328, which indicates that the explanatory degree of brand image value on the dependent variable rural revitalization effect is 32.8%, F=17.763, P<0.001. model 3 for the dependent variable rural revitalization effect has an R-squared change in the fit of 0.337, which indicates that the explanatory degree of brand association on the dependent variable is 33.7%, F = 16.443, P < 0.001.The amount of R-squared change in the fit of model 4 for the dependent variable rural revitalization effect is 0.345, indicating that the degree of explanation of brand identity on the dependent variable is 34.5%, F = 18.268, P < 0.001.The regression coefficients of the value of the IP image of the cartoon, the brand association, and the brand identity on the effect of rural revitalization are 7.623, 6.178, and 6.224, P < 0.001 respectively, 6.224, P < 0.001, indicating that comic IP image value, brand association and brand identity show a positive effect on rural revitalization. When the value of comic IP image, brand association and brand identity are increased by one unit respectively, the effect of rural revitalization is significantly increased by 6.178~7.623.

The regression analysis proves that the hypothesis is valid, i.e., the positive effect of comic IP image value, brand association and brand identity on rural revitalization is significant.

Table 2: The return of rural rejuvenation effect

| Variable | The effect of rural rejuvenation | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| Constant | 4.941*** | 3.461*** | 3.171*** | 3.246*** |
| Gender | 0.022 | 0.294 | 0.6 | 0.353 |
| Age | 0.015 | 0.713 | 0.2 | 0.464 |
| Educational background | 0.037 | 0.249 | 0.479 | 0.37 |
| Occupation | 0.079 | 0.599 | 0.485 | 0.361 |
| Personal income | 0.053 | 0.177 | 0.656 | 0.328 |
| IP image value | | 7.623*** | | |
| Brand association | | | 6.178*** | |
| Brand identity | | | | 6.224*** |
| R2 | 0.046 | 0.328 | 0.337 | 0.345 |
| F | 3.298*** | 17.763*** | 16.443*** | 18.268*** |

Note: *** is P < 0.001, i.e. passes the significance test at the 0.001 level.

## V. Conclusion

In this study, we successfully constructed the intelligent image generation model of Multi-shape Variation Generative Adversarial Network (MW-GAN) to realize the automatic generation of IP image characters for agricultural and sideline products cartoons in Jilin Province. The model effectively solves the problem of geometric variation diversity in the generation of IP image of agricultural and sideline products cartoon through the synergistic effect of style network and geometric variation network. The experimental results show that the model performs well in IS and FID metrics, reaching 94.91 and 6.63, respectively, which improves from 7.46% to 41.03% and reduces from 6.88% to 26.59% compared with the comparison method, proving the high quality and authenticity of the generated images. Regarding the recognition rate of frontalization of agricultural products, the model obtained excellent results at all angles, especially at extreme poses (75° and 90°), where the recognition rate reached 85.45% and 77.83%, respectively, demonstrating the strong adaptability of the model. The questionnaire survey of 600 consumers found that the average ratings of value, brand association and brand identity of the cartoon IP images of agricultural and

sideline products in Jilin Province were 4.319, 4.162 and 4.285, respectively, which were all higher than 4, indicating that consumers highly recognized these cartoon IP images. Regression analysis further confirms that the regression coefficients of value of comic IP image, brand association and brand identity on rural revitalization effect are 7.623, 6.178 and 6.224 ($P<0.001$), respectively, indicating that the rural revitalization effect is significantly improved from 6.178 to 7.623 units when these three factors are increased by one unit each. The research results not only realized the innovative application of AI technology in the image design of agricultural and sideline products, but also provided new ideas and practical paths for agricultural and sideline product branding and rural revitalization in Jilin Province.

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