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Graphic Design Application Based on Artificial Intelligence Image Recognition System

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ABSTRACT

The development of society has led to the continuous development and progress of artificial intelligence technology, and has also led to an increasing demand for graphic design. In order to better solve the problems of color deviation, poor design effect, and high design cost in traditional graphic design, this article applied artificial intelligence image identification system to graphic design to overcome the problems of traditional graphic design. The elements extracted from the graphic database were denoised and enhanced by means of mean filtering and histogram equalization; after image preprocessing, Deep Learning (DL) algorithms were used to construct an image identification system, and the modules and visualization interfaces of the system were introduced. Through experiments, it could be found that the average expert rating of the graphic design scheme designed by the DL based image identification system was 8.818 points, and the satisfaction rate of the 20 users selected for the DL based image identification system was above 93.4%. In summary, using DL to construct an image identification system and applying it to graphic design could effectively improve the overall effect of graphic design and increase user satisfaction with the designed graphic scheme.

Keywords: Graphic Design, Artificial Intelligence, Image Identification Systems, Deep Learning, Machine Learning

1. Introduction

The background of the development of artificial intelligence can be traced back to the 1950s [1], when people began to try to simulate the thinking and behavior of human intelligence. With the development of computer technology and increasing computing power, artificial intelligence has gradually become a hot topic in the field of science and technology. In the past few decades, AI technology has made great progress, especially in the fields of machine learning and deep learning, which has laid a solid foundation for the development of image recognition technology[2].

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With the continuous progress of computer vision and image processing technology, image recognition technology has been widely used in various fields. In the field of industrial manufacturing, image recognition technology can realize the automatic detection and quality control of products, avoid the impact of human factors on product quality, and then improve production efficiency and product quality [3-4]. In the field of security, more and more security systems through image recognition technology, can be realized on the scene of the people and objects in the rapid and accurate identification and monitoring, so as to improve security efficiency and judgment accuracy [5-6]. In the medical field, by analyzing and recognizing medical image data, it can help doctors diagnose diseases more accurately and improve the treatment effect and patient survival rate [7-9]. The importance of image recognition technology lies in its ability to bring more efficient production methods, safer and more reliable monitoring means, and more accurate medical diagnosis and treatment methods to various industries. From simple QR code scanning to complex face recognition systems, image recognition technology has become an indispensable part of modern society [10]. The development background of artificial intelligence provides a broader development space for image recognition technology and brings more possibilities and opportunities for various industries.

In modern society, visual communication is more and more important, and people pay more attention to its visual effect and expressive ability for some information with specific purposes. In this context, graphic design, as a communication tool, has become an important means of commercial publicity, cultural heritage and brand building [11]. In graphic design, the designer determines the corresponding design scheme according to various considerations such as brand positioning, product attributes and target audience, so that the designed works have a clear positioning and form brand image and product image in the market [12-14]. At the same time, make the brand, company, organization or product in the market through a certain logo, brand elements or image spokesman and other means, in the minds of consumers to form a cognitive, easy to identify, remember and transfer [15-16]. In the field of graphic design, the image recognition technology of artificial intelligence has gradually begun to be applied.

The production characteristics of each period would have a certain impact on the characteristics of art. With the continuous development of technology, art is more perfectly and vividly displayed in people's vision, triggering new "thinking" and new social values. The development of artificial intelligence technology has led to widespread application of image identification technology. Graphic design also plays a very important role in many fields, and the development of artificial intelligence image identification systems has brought new development space for graphic design. The image identification technology formed by artificial intelligence mainly uses computer technology to process images, and then obtains the final processed images through the staff. The overall technical principle is relatively simple, which is conducive to overcoming the problems of complex operations, high operating costs, and low accuracy of traditional image identification. Therefore, this article applied the artificial intelligence image identification system to graphic design. By combining graphic design with artificial intelligence, it is found that it could effectively improve design efficiency, and expand creative space, so as to achieve the best user experience and graphic image creation, and extract image data more accurately through the artificial intelligence image identification system.

2. Design and Implementation of an Artificial Intelligence Image Identification System

2.1. Dataset Preparation and Annotation

After the design task is clarified, the first thing to do is to collect data. Data collection is the foundation of design, and the quality of the collected data directly affects the overall level of design. Usually, stakeholders would provide some information, and designers can build on this information. When faced with a large amount of data information occurring simultaneously, many people always

try to categorize these data and distinguish between useful and unnecessary data information. This is what graphic designers need to accomplish first. Graphic designers would collect data related to design and record this data. Identifying and establishing the relationships between different groups of conflicting information is the most challenging part in graphic design. The graphic design database is shown in Figure 1.

Fig. 1. Graphic design database

At present, computer graphics image processing technology is more and more widely used in real life. The calculation method is as follows:

$$q_{ij} = sigmoid\left(\log its_{ij}\right) = \frac{1}{1+e^{-\log its_{ij}}} \tag{1}$$

$\log its_{ij}$ represents the estimated tag value of the image, and q_{ij} represents the value calculated by the activation function of the image.

Assuming that the true value of the label corresponding to the input image is x, the formula for calculating model loss is as follows:

$$loss_{ij} = -\left[x_{ij} * \ln q_{ij} + \left(1-x_{ij}\right)\ln\left(1-q_{ij}\right)\right] \tag{2}$$

Among them, x_{ij} represents the $j-th$ true value of the $i-th$ image.

Every time an image is correctly classified, the image feature center is updated. The calculation formula is as follows:

$$Q_q = \frac{\left(\left(\sum_{i=q}^{i=m-1} Arr_{ij} / m\right) / n - Q_q\right)^2}{2} \tag{3}$$

In the process of scene imaging, spatial sampling, and quantization, images are often affected by various external noise, thereby reducing image quality. Image noise is the most direct problem that directly affects the human eye's image observation. In order to minimize noise as much as possible, it is necessary to denoise the images contaminated by noise. Mean filtering and median filtering can be used to process the images, and mean filtering is the focus. By studying images of different sizes and adding corresponding image content, the quality of the images can be improved to achieve the best

image identification results. The comparison effect of using mean filtering to denoise the image is shown in Figure 2.

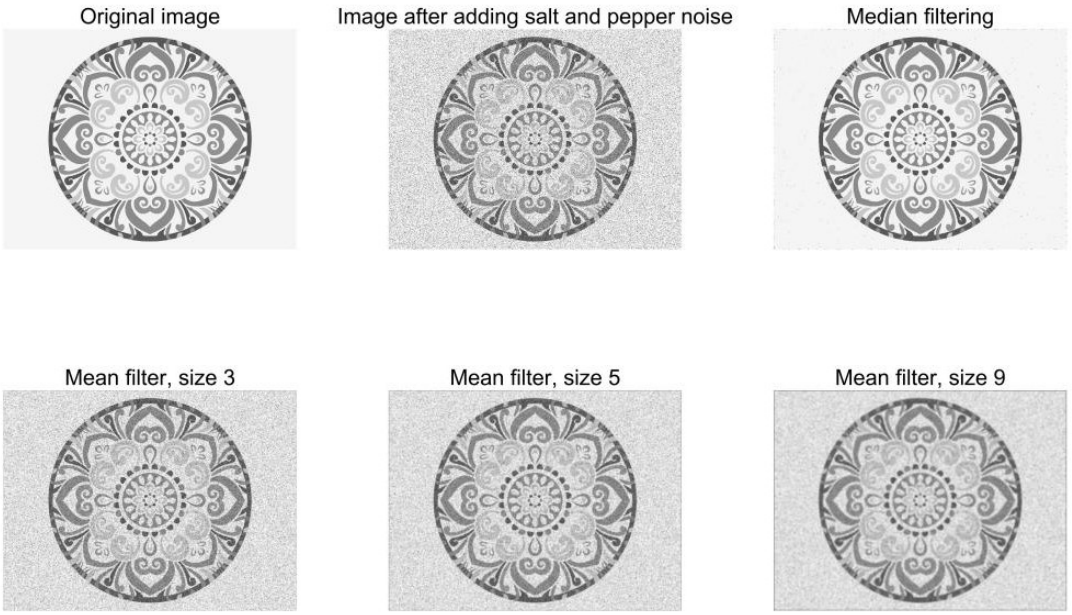


Fig. 2. Image denoising and contrast effect using mean filtering

The mean filtering algorithm is an important component of image modeling and is commonly used for processing noisy images. It can filter out unnecessary noise related to image strength. The specific expression is as follows:

$$q\left(y_i, b_i\right)=\sum_{j=1}^{M} b_j \frac{1}{\sqrt{2\pi\left|\sum j\right|}} e^{-0.5\left(y_i, \theta_j\right) \sum_j^{-1}\left(y_i, \theta_j\right)} \tag{4}$$

Among them, $q\left(y_i, b_i\right)$ represents the pixels of the selected image.

The histogram equalization algorithm is a special method for image processing. For the image data processed by this method, the contrast of the pixels at the top of the histogram is improved, while the contrast at the bottom of the histogram is reduced. This gradually displays local image information in the output histogram, thereby improving the contrast of the image and improving the subjective visual effect of the image data. In order to see the effect more intuitively, histogram equalization is used to process an image in the graphic design database. The processed effect is shown in Figure 3.

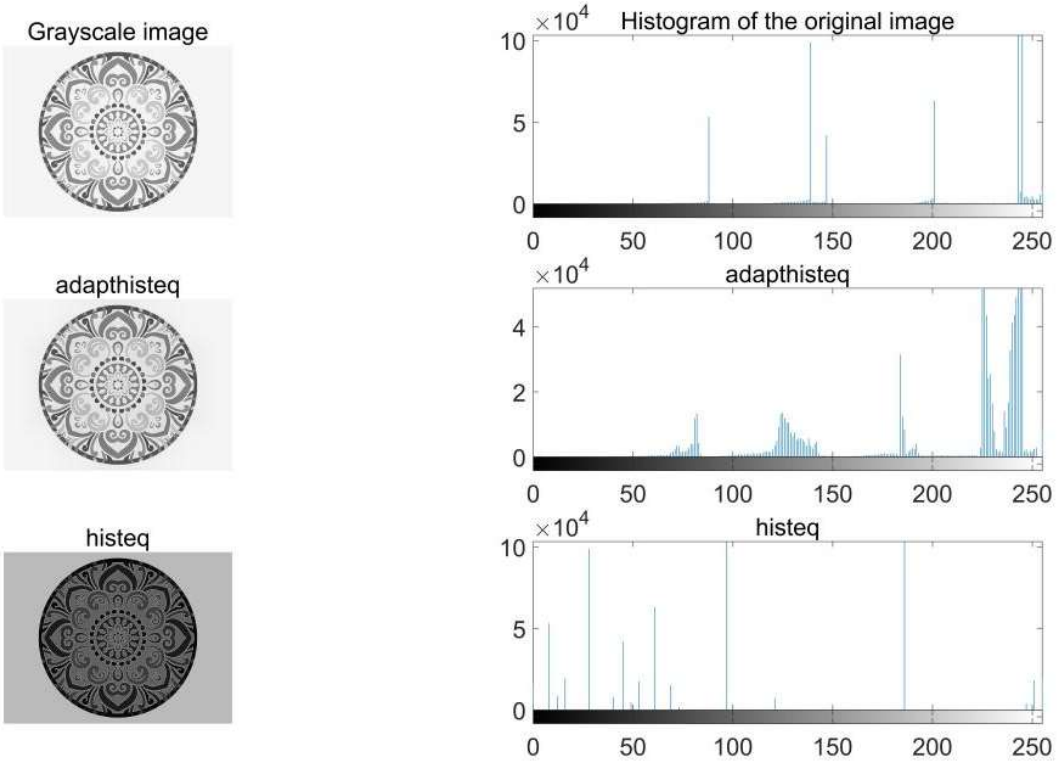


Fig. 3. Image processing effect of histogram equalization algorithm

At the same position, there are usually three independent light signals, and the relationship between pixels and input light signals in the photo system is simulated as follows:

$$\theta^{(n)} = Q^{(n)}\left(v^{(n)}\right) = \int H(\gamma) R^{(n)}(\gamma) d(\gamma) \tag{5}$$

Among them, $\theta^{(n)}$ is an identity function; $v^{(n)}$ is the response value of the $n-th$ channel; $R^{(n)}$ is the camera sensor's response function for the $n-th$ channel; $R^{(n)}(\gamma)$ is a linear transformation for the color matching function.

The calculation formula of histogram equalization is as follows:

$$\begin{cases} Ravg = \sum_{t=1}^{M}\sum_{k=1}^{N} R_{tk} \\ Gavg = \sum_{t=1}^{M}\sum_{k=1}^{N} G_{tk} \\ Bavg = \sum_{t=1}^{M}\sum_{k=1}^{N} B_{tk} \end{cases} \tag{6}$$

Among them, $Ravg$, $Gavg$, and $Bavg$ represent the common colors of the image.

The larger the selected neighborhood at the edge details of the image, the greater the degree of blur in the preprocessed image. Introducing a threshold can reduce blurring effects, and the mean method is defined as follows:

$$P_{xy} = \begin{cases} \dfrac{1}{tk}\sum_{(x,y)\in(t,k)} g(x,y) & \left| g(x,y) - \dfrac{1}{tk}\sum_{(x,y)\in(t,k)} g(x,y) \right| > W \\ g(x,y) & other \end{cases} \tag{7}$$

Among them, P_{xy} represents the edge value of the image, and $g(x,y)$ represents the selected image.

2.2. System Design

DL has developed NN technology and has been widely applied in the field of Machine Learning (ML), which can be used to solve many practical problems and has achieved great success in image identification. For images, the processing sequence is generally to first obtain the edges of the image, then create the first image, and finally merge it into multiple complex images. The model of DL is multi-layer, with many matching neurons, and the first layer in the network usually contains edge data. Meanwhile, as the number of layers increases, more uncertainty is obtained. DL can be used in many applications, and supervised learning is one of the main manifestations of DL.

Convolutional layer, also known as feature extraction layer, is mainly used to extract image features through convolution. The specific expression is as follows:

$$y_i^k = h\left(\sum_{j \in N_j} y_i^{k-1} * g_{ij}^k + x_j^k \right) \tag{8}$$

The $i-th$ feature map of the convolution layer k is represented by y_i^k, and h is the activation function in the convolution operation.

A basic form of logistic regression is a kind of regression for multi class classification problems, which solves the problem when different data are mutually exclusive. The expression is as follows:

$$f(\theta) = -\frac{1}{n}\left[\sum_{i-1}^{n}\sum_{j-1}^{m} 1\left\{ x^{(i)} = i \right\} * \log\left(q\left(x^{(i)} = i \mid x^{(i)}; \theta \right) \right) \right] \tag{9}$$

Among them, f represents the mean square deviation between the predicted value of the given function and the actual value of x, which reflects the degree of deviation between the predicted value and the actual value.

For DL image identification systems, training and testing are the most important parts of the system. Testing refers to obtaining recognition results of some images based on patterns and their parameters, so as to determine the quality of the training mode. On the results page, users can select the images they want to see one by one, and support classified viewing, ensuring that users can find specific types of images every time. When displaying the results, the results of image identification and image annotation would be displayed simultaneously. The position of the target is marked with a box, and the type of each target is displayed in a list. By using a graphical interface to set parameters for calling images for recognition of other images, the system can also be published online, and others can recognize the uploaded images through a browser. The specific module diagram of the system is shown in Figure 4.

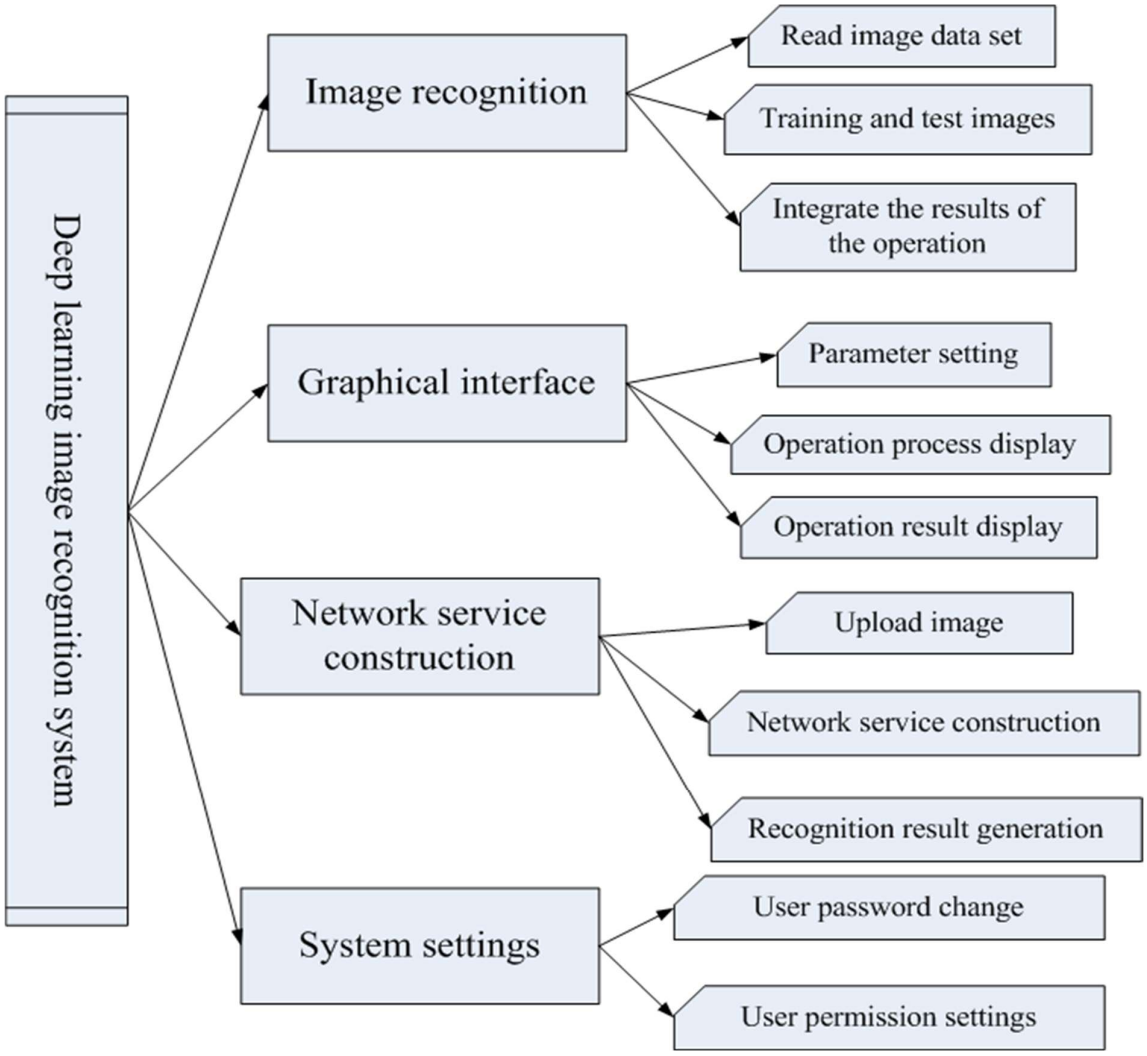


Fig. 4. System module diagram

2.3. Module Detailed Design

During the evaluation phase, descriptions of the training and testing processes, as well as validation results of the testing process, can be obtained. By reading this information, the relationship between each region in each image and the target size is calculated. In the application stage, the reason for accepting the testing method is calculated based on the reference data obtained through training regarding the relationship between target position and size. The usage method of training images and testing evaluation images is the same, both of which are set by modifying parameters, then importing processing code, and then inserting analysis steps. Finally, the execution code can be run. During the operation process, the interface would display the progress status, and users can judge the operation status based on the status. If it is not normal, they can make modifications. The schematic diagram of training and testing images is shown in Figure 5.

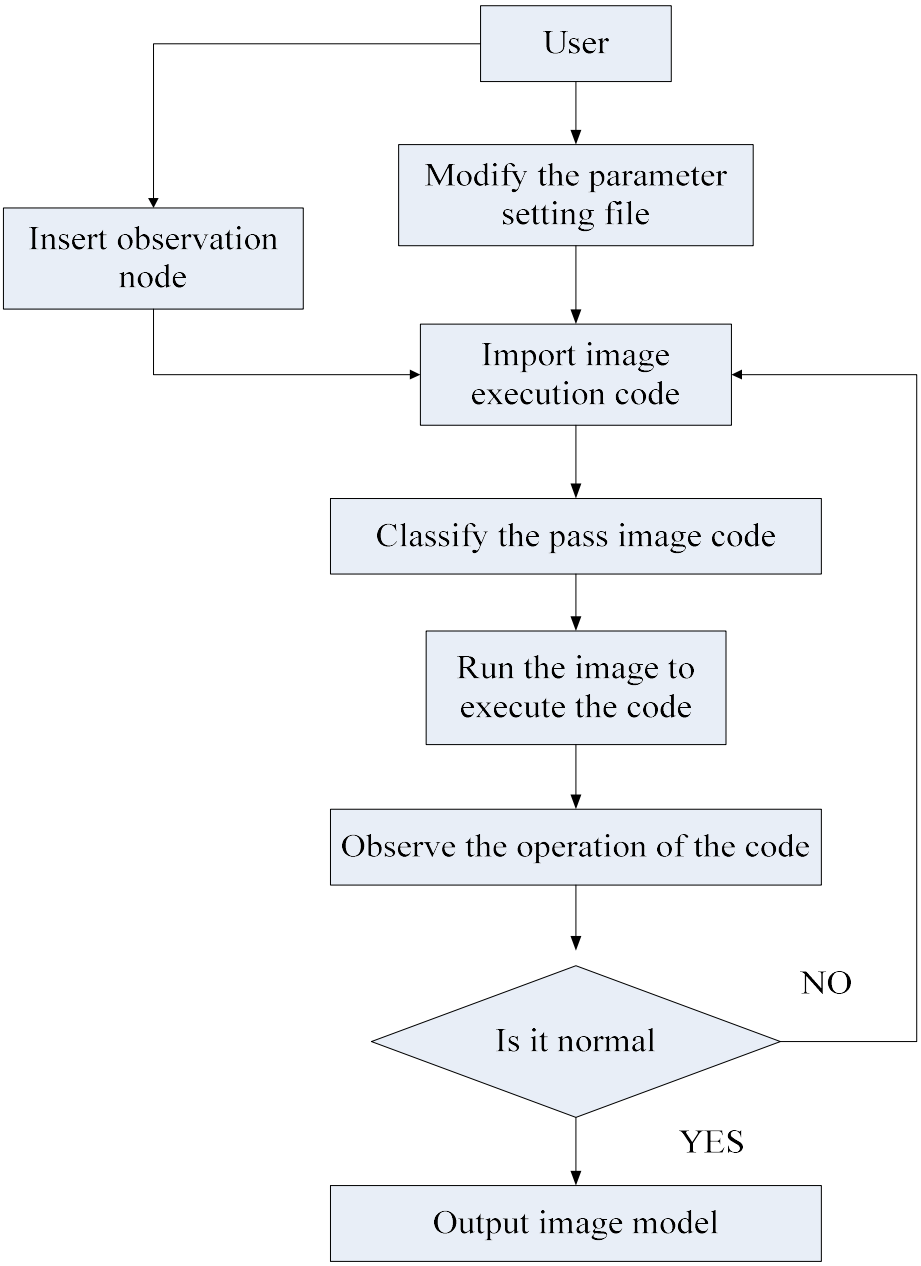


Fig. 5. Schematic diagram of training and testing

2.4. Design Requirements and Interaction Design

According to the needs of graphic design, suitable user interfaces are created, allowing users to understand and communicate graphic design on the created DL image identification system. The human-machine interface should be able to easily handle different interactive tasks. The output of the problem should be easy to understand and have less additional information. It can directly process image data, with a high degree of automation and ease of business operations. It can display the results of graphic design to users based on tables or graphical methods. The language used in human-machine interfaces should be standardized and consistent, especially in professional terms, which must be maintained consistently. The interface of the image identification processing system is shown in Figure 6.

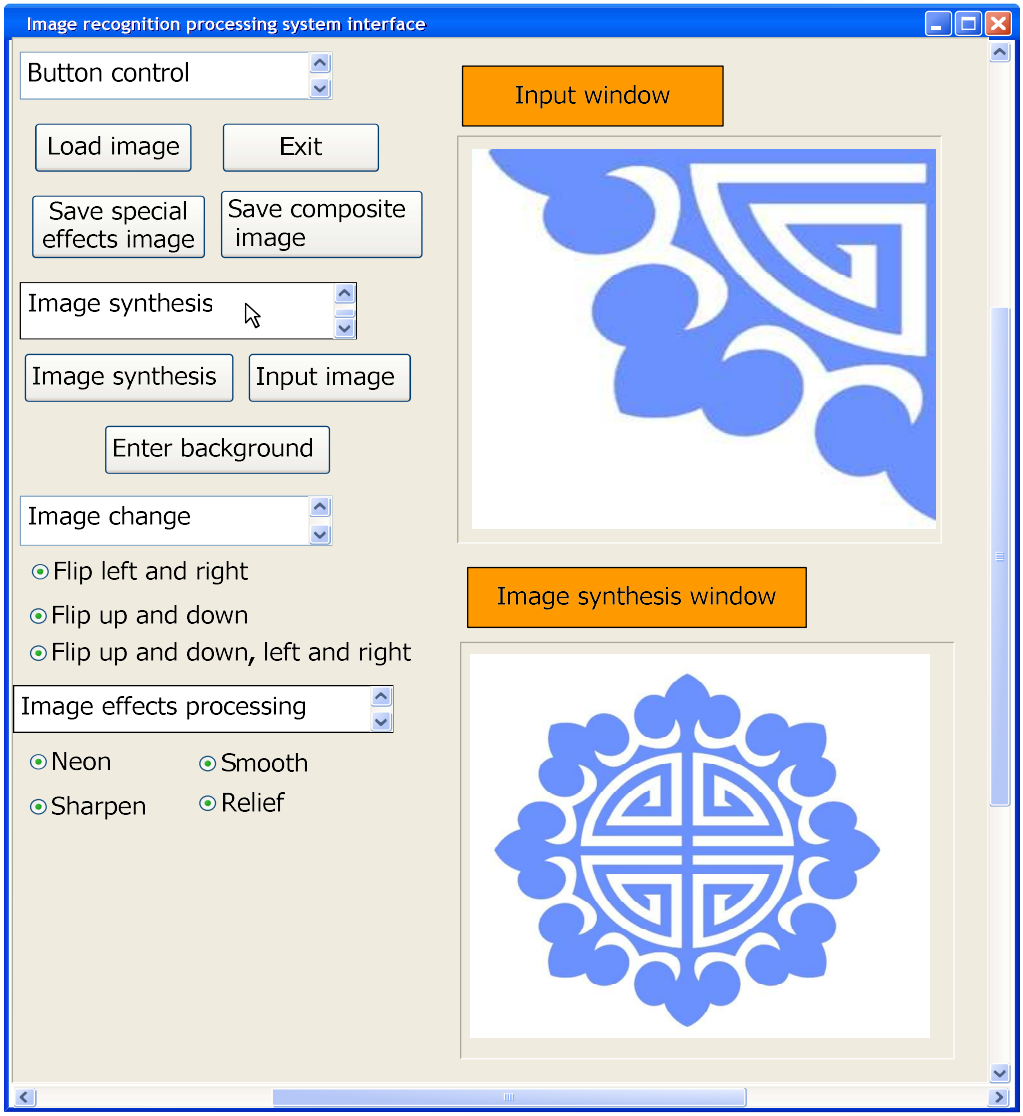


Fig. 6. Image identification processing system interface

3. Application Practice and Case Evaluation of Graphic Design

Motion graphics design is also called dynamic design for short. Motion graphics design involves many aspects. It is based on a certain static view and reconstructed into an image that would move and change in a period of time through animation software. Motion graphics design is different from traditional graphics. It has no clear lines and boundaries. It is an art discipline that integrates multiple technologies and expands multiple categories. Motion graphics design is not only a concept in graphic design, but also a teaching and skills based on movies and graphics. Animation design involves creating images in cartoons like comics. It can be seen that the main difference between graphic design and behavioral animation design lies in their different content. The specific differentiation is shown in Table 1.

Table 1. Comparison of differences between animation design and graphic design

Distinguishing criteria	Graphic design	Animation design
Performance center of gravity	Figurative products and graphics as the carrier	Take the character as the carrier
Exercise method	Abstract movement-based	Centered on the logical movement of the plot
Narrative center	Centered on explanatory narrative	Centered on the storyline
Design focus	Centered on graphic design	Centered on script and art design
Application area	Graphic design, packaging, advertising	Movies, TV
Communication of information	Product promotion, visual experiment	Thoughts on the theme of a certain story
Use object	Widely used objects	Smaller used objects

When users view a well-designed graphic design work, the display of details can help the audience understand the design of the work. However, when users deeply understand the graphic design work, understanding the specific design process can help them have a deeper understanding of the graphic design work. The image processing interface of the DL image identification system is opened, and two graphics are randomly selected from the database, which can be automatically generated by the software or already created by others. One is used as the main image and the other as the background image. The second step is to load the background image into the image window, and then load the second image into another window. The third step is to click the image synthesis command button to form a complex graphic design as shown in Figure 7. The fourth step is to save the image to the computer disk.

Fig. 7. Complex graphic design based on image identification system

The DL based image identification system is applied to graphic design, and the images that need to be processed are input into the image identification system. According to different processing

requirements, different choices are made in the system to output the processed images. In order to make a significant difference in the graphics, some changes can be made to the graphics, such as flipping left and right, flipping up and down, flipping up, down, left and right, etc. These changed graphics can be combined to obtain more exquisite and complex graphics. Figure 8 shows the flipping situation of the image that needs to be designed, and Figure 9 is a complex graph formed based on Figure 8.

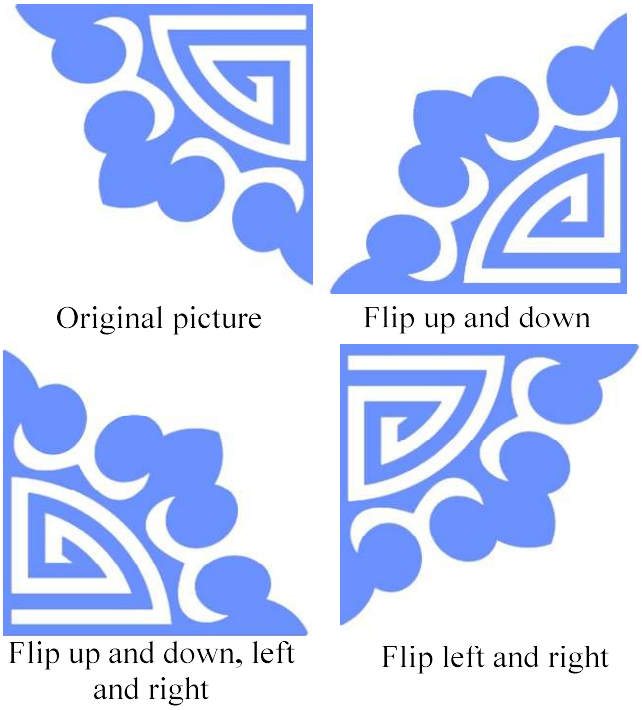


Fig. 8. Using the system for graphic flipping design

Fig. 9. Overall image of graphic design

4. Evaluation of the Application of DL Based Image Identification Systems in Graphic Design

By using different systems and software to design graphics and using the same graphics for the same image, the resulting results are all different. In order to better evaluate the graphic design schemes of image identification systems based on DL, 20 experts were randomly selected to rate 10 graphic design schemes. The score is 1-10 points. The higher the score, the higher the overall evaluation of the work. The evaluation mainly focuses on the visual perception, color, design speed, and overall aesthetics of image design. The result of expert scoring is compared with the graphic design scheme designed by the image identification system based on Computer Aided Design (CAD), Photo Shop (PS), NN and ML. The final rating for 10 graphic design solutions is based on the average score of 20 experts. The specific scoring situation is shown in Table 2.

Table 2. Expert scoring

Graphic design number	DL	CAD	PS	NN	ML
1	8.85	8	7.71	8.35	8.3
2	8.65	7.85	7.75	8.2	8.3
3	8.88	7.35	7.55	7.95	8
4	8.95	7.7	7.85	8	8
5	8.65	7.64	7.65	8	8.4
6	8.45	7.65	6.85	8	8.35
7	8.75	8.05	7.75	8.1	8.2
8	8.9	8.15	7.85	8.15	8.15
9	9.1	7.9	6.9	8.1	8
10	9	7.95	7.7	8.2	8.25

As shown in Table 2, there were 10 graphic design schemes designed by five different image identification systems, and the average score of 20 experts on these 10 schemes. The expert ratings for the 10 schemes of the DL based image identification system were all above 8.44 points; the expert scores for the 10 graphic design methods designed based on CAD, PS, NN, and ML image identification systems were below 8.16, 7.9, 8.36, and 8.41, respectively. The expert rating for the graphic design scheme designed by DL based image identification systems was much higher than that of other image identification systems. In order to further investigate the superiority of the graphic design schemes designed for DL based image identification systems, a study was conducted on the 10 graphic design schemes in Table 2. The specific comparison results are shown in Figure 10.

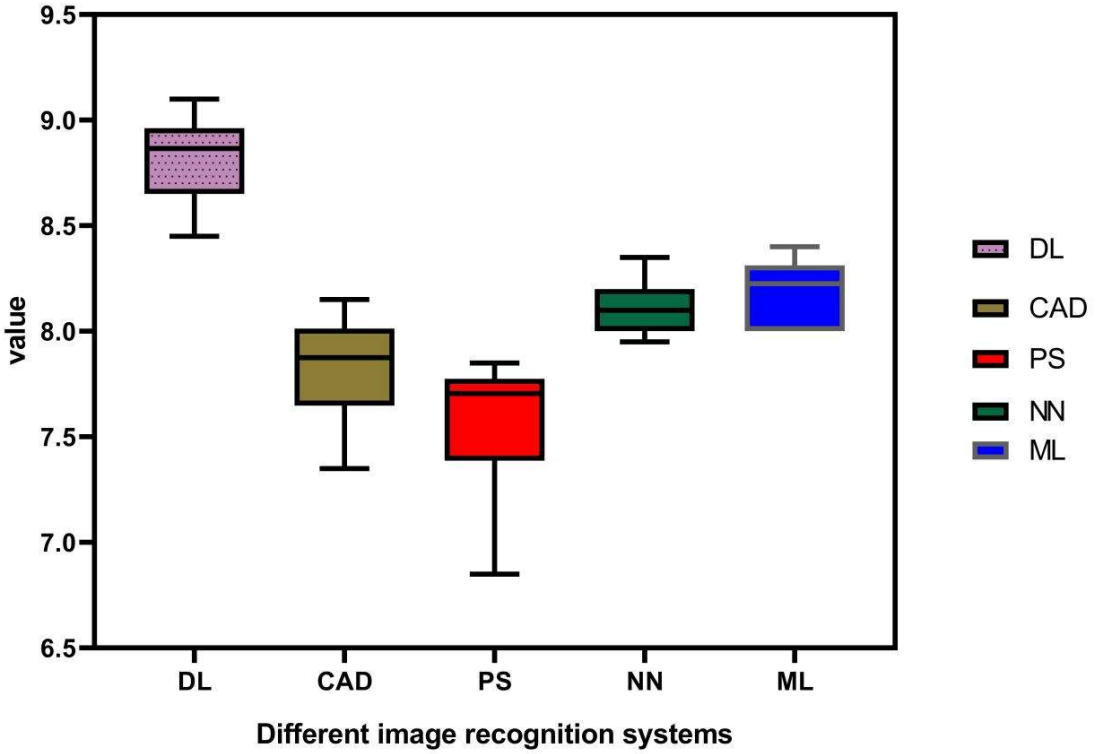
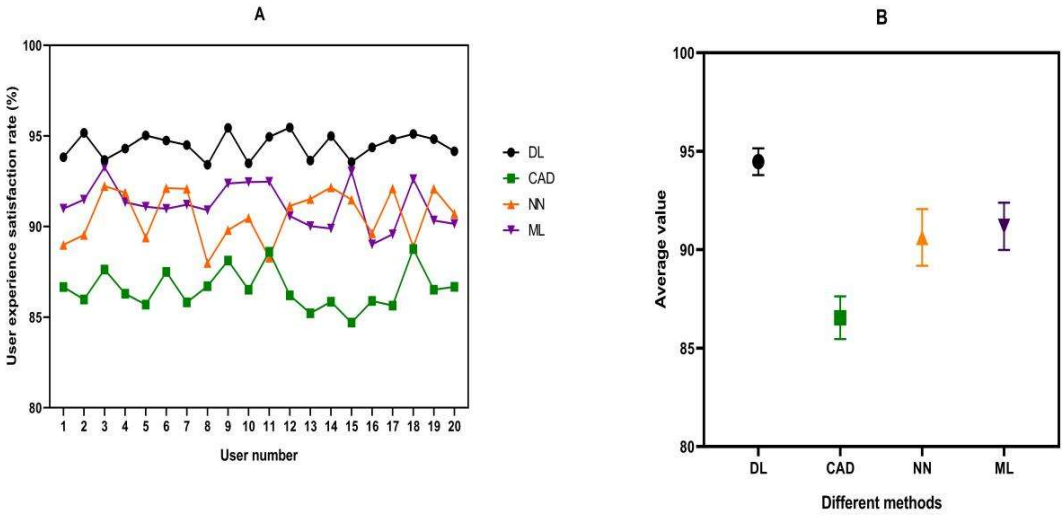


Fig. 10. Five different systems and software expert ratings

In Figure 10, the x-axis represents different image identification systems, and the y-axis represents the expert scoring values. The elements represent the minimum to maximum, while the horizontal line in the middle represents the average value. As shown in Figure 10, the minimum expert rating of the graphic design scheme designed by the DL based image identification system was much higher than the maximum rating of other system design schemes, and the average value was also much higher than the expert rating of other systems. The average expert rating for graphic design solutions designed by DL based image identification systems was 8.818 points, which was 0.994 points, 1.262 points, 0.713 points, and 0.623 points higher than the average expert rating for graphic design solutions designed by the other four systems based on CAD, PS, NN, and ML, respectively. Among them, the average score of the scheme designed by the ML based image identification system was lower than that of the system expert based on DL, but higher than the other three, while the overall score of the PS based image identification system was the worst.

The satisfaction rate of users with a system experience is also an important evaluation aspect that determines the quality of a system. The higher the user experience satisfaction rate, the better the performance of the system in all aspects. Conversely, if the satisfaction rate is lower, it indicates that there is a certain problem with the overall performance of the system. The user experience satisfaction rate of the DL based graphics recognition system is very high. In order to further demonstrate its superiority in user experience satisfaction rate, 20 users were randomly selected and their system experience satisfaction rate was surveyed. At the same time, the survey results were compared with image identification systems based on CAD, NN, and ML. The specific user experience satisfaction rate comparison results are shown in Figure 11.



A: Satisfaction comparison B: Average satisfaction rate

Fig. 11. Comparison of user experience satisfaction rates among different image identification systems

In Figure 11A, the x-axis represents the number of 20 extracted users, while the y-axis represents the user experience satisfaction rate; In Figure 11B, the x-axis represents the different extracted systems, and the y-axis represents the average user experience satisfaction rate. As shown in Figure 11, the user satisfaction rate with DL based image identification systems was much higher than the other three systems. This was because using DL's image identification system could help users design more excellent graphic designs, improve the overall presentation effect of graphic designs, and make colors more colorful. Different special effects could be added to make the design more visually appealing. As shown in Figure 11A, the user experience satisfaction rate of DL based image identification systems was above 93.4%, while the user experience satisfaction rates of CAD, NN, and ML based image identification systems were below 88.77%, below 92.24%, and below 93.29%, respectively. The 8th user had the lowest satisfaction rate with the DL based image identification system experience, which was only 93.41%. However, this was still 6.7%, 5.42%, and 2.51% higher than the user experience satisfaction rates of image identification systems based on CAD, NN, and ML, respectively. The 18th user had the highest satisfaction rate with the experience of CAD based image identification systems, which was 88.76%. However, this was still 6.35% lower than the DL based image identification system; the third user had the highest satisfaction rate with the experience of image identification systems based on NN and ML, which were 92.23% and 93.28%, respectively. However, the user experience satisfaction rates of these two image identification systems were still 1.44% and 0.39% lower than those of DL based image identification systems, respectively. As shown in Figure 11B, the user experience satisfaction rate of the selected 20 users based on DL image identification system was 94.47%, which was 7.92%, 3.85%, and 3.28% higher than that of the image identification system based on CAD, NN, and ML, respectively.

For image identification systems, the accuracy of identifying different graphic designs was beneficial for helping designers better carry out graphic design. The image identification system was used to recognize eight types of graphic design, including positive and negative graphics, symbiotic graphics, ghosting graphics, pun graphics, isomorphic graphics, textual graphics, gradient graphics, and overlapping graphics. Through experiments, it could be found that the DL based image identification system had very high accuracy in recognizing these 8 different types of graphic designs. The experimental results are compared with the image identification systems based on CAD, NN, and ML, and the specific recognition accuracy comparison results are shown in Table 3.

Table 3. Accuracy of four image identification systems in identifying different graphic design types

Graphic design type	DL	CAD	NN	ML
Positive and negative graphics	93.44	88.23	92.22	91.05
Symbiotic graphics	95.71	86.51	91.48	90.57
Different shadow graphics	93.49	88.69	89.62	92.01
Pun graphics	94.95	87.82	91.87	90.27
Isomorphic graphics	92.39	86.97	90.81	91.58
Text graphics	93.68	85.85	90.12	91.17
Gradient graphics	94.99	84.77	90.77	90.85
Transparent graphics	93.58	85.89	91.59	92.31

As shown in Table 3, the accuracy of DL based image identification systems for recognizing these 8 different types of graphic designs was much higher than that of the other three image identification systems. Among them, the DL based image identification system had a recognition accuracy of over 92.38% for different types of graphic designs. The recognition accuracy of image identification systems based on CAD, NN, and ML for different types of graphic designs was below 88.7%, below 92.23%, and below 92.32%, respectively. The DL based image identification system had the lowest recognition accuracy for isomorphic graphic designs, which was only 92.39%. However, this was still 5.42%, 1.58%, and 0.81% higher in recognition accuracy than image identification systems based on CAD, NN, and ML; the DL based image identification system had the highest recognition accuracy for symbiotic graphic design, which was 95.71%. This was 9.2%, 4.23%, and 5.14% higher in recognition accuracy than image identification systems based on CAD, NN, and ML. The image identification system based on CAD had the highest recognition accuracy for ghosting graphic design, which was 88.69%. However, this was still 4.8% lower than the recognition accuracy of DL based image identification systems; the image identification system based on NN had the highest recognition accuracy for positive and negative graphic designs, which was 92.22%. However, this was still 1.22% lower than the recognition accuracy of DL based image identification systems; the ML based image identification system had the highest recognition accuracy for overlapping graphic designs, which was 92.31%. However, this was still 1.27% lower than the recognition accuracy of DL based image identification systems.

5. Discussion on the Application of Artificial Intelligence Image Identification Systems in Graphic Design

5.1. Extracting Typical Features of Images

The main process of ensuring image feature extraction is selection and extraction. Everything in this world has its own characteristics, and each of them has the same characteristics in artificial intelligence image identification systems. Being able to choose research and content suitable for image identification is a solid foundation for ensuring the integrity and accuracy of final image identification. Through most current applications of image identification, it can be seen that the most important features of image identification are the shape, color, and texture of the image. Generally speaking, in image identification, the first thing to be recognized is the color of the object, and then specific information such as the position and volume of the recognized object is captured. However,

when using image identification as a special tool, it is necessary to consider the usage scenario and the purpose that the technology aims to achieve, so as to set the priority of authentication. Each image has many points when viewed from different perspectives. Therefore, in order to obtain clear images, it is necessary to divide and classify the features of the images.

5.2. Intelligence

The intelligence of image identification processing is the biggest advantage of image identification technology in artificial intelligence. Especially compared to traditional image processing technologies, artificial intelligence image identification technology can intelligently select and analyze images, and has functions that other recognition technologies do not have. These image identification tools can not only display simple images, but also process, manage, and analyze image data, which is not easily achieved by traditional computer image processing functions.

6. Conclusions

With the development of artificial intelligence technology, the value of image identification technology lies in allowing computers to process a large amount of graphic information. The processing process is to collect graphic information to extract features from this information, and then classify and recognize graphics based on the extracted features. At the same time, image identification based on artificial intelligence has a unique advantage in the accuracy of graphic information recognition. As images focus more on the content itself, complex data information becomes apparent, and graphic design cannot be displayed in a dynamic and visible manner. image identification systems based on artificial intelligence can intelligently process images. Therefore, this article applied artificial intelligence image identification systems to graphic design to improve user satisfaction and better present graphic design to users.

References

[1] Wooldridge, M. (2021). A brief history of artificial intelligence: what it is, where we are, and we are going. Flatiron Books.

[2] Liu, L., Wang, Y., & Chi, W. (2020). Image recognition technology based on machine learning. IEEE Access.

[3] Chunhachatrachai, P., & Lin, C. Y. (2024). Automated Angle Detection for Industrial Production Lines Using Combined Image Processing Techniques. Intelligent Automation & Soft Computing, 39(4).

[4] Rahmatov, N., Paul, A., Saeed, F., Hong, W. H., Seo, H., & Kim, J. (2019). Machine learning–based automated image processing for quality management in industrial Internet of Things. International Journal of Distributed Sensor Networks, 15(10), 1550147719883551.

[5] Gayam, S. R. (2024). Deep Learning for Image Recognition: Advanced Algorithms and Applications in Medical Imaging, Autonomous Vehicles, and Security Systems. Hong Kong Journal of AI and Medicine, 4(1), 223-258.

[6] Renuka, B., Sivaranjani, B., Lakshmi, A. M., & Muthukumaran, D. N. (2018). Automatic Enemy Detecting Defense Robot by using Face Detection Technique'. Asian Journal of Applied Science and Technology, 2(2), 495-501.

[7] Efimenko, M., Ignatev, A., & Koshechkin, K. (2020). Review of medical image recognition technologies to detect melanomas using neural networks. BMC bioinformatics, 21, 1-7.

[8] Chen, W., Yao, M., Zhu, Z., Sun, Y., & Han, X. (2022). The application research of AI image recognition and processing technology in the early diagnosis of the COVID-19. BMC Medical Imaging, 22(1), 29.

[9] Prados-Privado, M., Villalón, J. G., Martínez-Martínez, C. H., & Ivorra, C. (2020). Dental images recognition technology and applications: a literature review. Applied Sciences, 10(8), 2856.

[10] Huo, L., Zhu, J., Singh, P. K., & Pavlovich, P. A. (2021). Research on QR image code recognition system based on artificial intelligence algorithm. Journal of Intelligent Systems, 30(1), 855-867.

[11] Walker, S. (2017). Research in graphic design. The Design Journal, 20(5), 549-559.

[12] Ni, W. (2024). Brand Image Building: The Key to Graphic Design. Journal of New Media and Economics (ISSN: 3005-5725), 1(3), 115.

[13] Wang, F., & Chen, H. (2022). Visual communication method of graphic language in industrial product design. International Journal of Product Development, 26(1-4), 1-11.

[14] Buryk, D., & Holubets, I. (2023). SUCCESSFUL CASES OF BRANDING THROUGH GRAPHIC DESIGN: ANALYSIS OF SPECIFIC CASES WHERE GRAPHIC DESIGN INFLUENCED BRAND SUCCESS. Scientific Journal of Polonia University, 61(6), 32-37.

[15] Barnes, A. (2017). Telling stories: The role of graphic design and branding in the creation of 'authenticity'within food packaging. International Journal of Food Design, 2(2), 183-202.

[16] Tian, Z. (2020). Dynamic visual communication image framing of graphic design in a virtual reality environment. Ieee Access, 8, 211091-211103.