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Enhanced Plant Image Recognition Using AlexNet and Deformable Convolution with Preprocessing Techniques

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Abstract:

Plant image recognition plays a vital role in botany and machine learning, yet challenges such as noise, occlusion, and unclear images limit classification accuracy. This paper proposes an improved deep learning framework based on the AlexNet convolutional neural network (CNN) for plant image recognition. To address issues of incomplete features and noise, we integrate deformable convolution layers and apply image preprocessing techniques, including Gaussian filtering and edge enhancement, using OpenCV and PyQt5. Transfer learning is employed to update the model with large-scale plant datasets, enhancing adaptability to diverse plant species. Experimental results demonstrate that the enhanced AlexNet model achieves over 98% accuracy in recognizing ten plant species, surpassing traditional CNN approaches in both efficiency and precision. The findings underscore the potential of combining advanced CNN architectures with preprocessing to achieve robust plant image classification.

Keywords:

pyqt 5; Opencv; Loss Function; Plant Image Recognition.

1. Background and Meaning

Plant image recognition is an important subject [2] in the field of botany, from the rise of artificial intelligence to now over the years has formed a systematic classification system, but for the outdoor or other occasions to identify plant species or plant leaves and so on texture analysis, still need a lot of researchers spend a long time to identify and can not guarantee a good accuracy. For a plant, when researchers observe it, they generally focus on the characteristics of the stamens or the pattern and texture of the leaves, the color, the shape and the related information. After collecting the recognizable information, the researchers will compare it with the plant database to finally determine the category of the plant. Based on this idea, We came up with the idea of building simple neural networks for the classification and recognition of plant images, With the continuous strengthening of the computer performance, For the training of the model as well as the integrated loading of the dataset, Become more and more rapidly, But as for plant image recognition, The image to be identified is not necessarily clear and flat, Shmay be loom in the picture, Noise point, There are many situations, such as foreign bodies, All of these reasons will cause the loss of the main information of the picture, Thus, affecting the judgment of the classification model, Reduce the accuracy of the image feature extraction and thus disturb the accuracy of the recognition, So we add to the processing of the pictures, For the processed pictures, Our model can be extracted from the new pictures to have more relevant information to help our model to identify, So add the image recognition technology for image processing, Has been widely used in various image recognition fields.

Currently, There are also many research results on the classification of plant image recognition, Plant image recognition also serves as an important branch in the field of machine learning, 2011 by Columbia University Professor Peter Belhumeur, University of Maryland professor David Jacobs and botanist John Kress from the Smithsonian Museum jointly formed a Leafsnap development team,

With its collaborators on the world's first plant leaf recognition software on the Apple ios [3] system, in this software, We can take pictures and then artificially cut off the leaves of the plant, Then the plant leaf identification system was used to identify the leaf. In 2015, Zheng Jiao [4] et al. developed a rice disease image recognition system based on the Android system, The underlying conditions for this recognition, Is the artificial extraction of various information from plants, Transformed into a machine to extract the plant color features, Various features, such as texture features and shape features, Then we used the dimension reduction and backward propagation neural network for classification, This represents a great improvement over the previous recognition systems, In 2016, Huang Jie et al. proposed a scale-invariant feature transformation algorithm with preprocessing, Can identify the types of fifty-three-clock plants, Type you have been a big improvement compared to the previous system, But for the accuracy of the identification, speed, Model processing mode and so on still has a great deficiency, So most of the plant recognition software on the market has different functions and effect levels, The recognition accuracy rate is also relatively inaccurate.

Deep learning technology has been increasingly used in the image recognition field, Such as the license plate detection, Face detection, Handwritten font recognition [5], etc., Compared to the old version of the recognition system, The new version of the recognition system has the following benefits, Not only can automatic preprocessing and feature extraction of the identified plants, You can also package it by yourself after processing it, In our present experiment, We mainly adopted the AlexNet model in the CNN convolutional neural network to perform the feature extraction and classification of plants, For identifying a larger variety of plants, We adopted the transfer learning method to update the model and identify the image after the classification, In the entire model treatment, We all performed the parallel algorithm design based on the GPU, The advantage of this approach is that for us, we can identify more plants, Faster identification of plants and more accurate identification of plants, In the process of updating and iteration, The model will gradually be satisfied with our expected results

2. Basic Process of Image Recognition

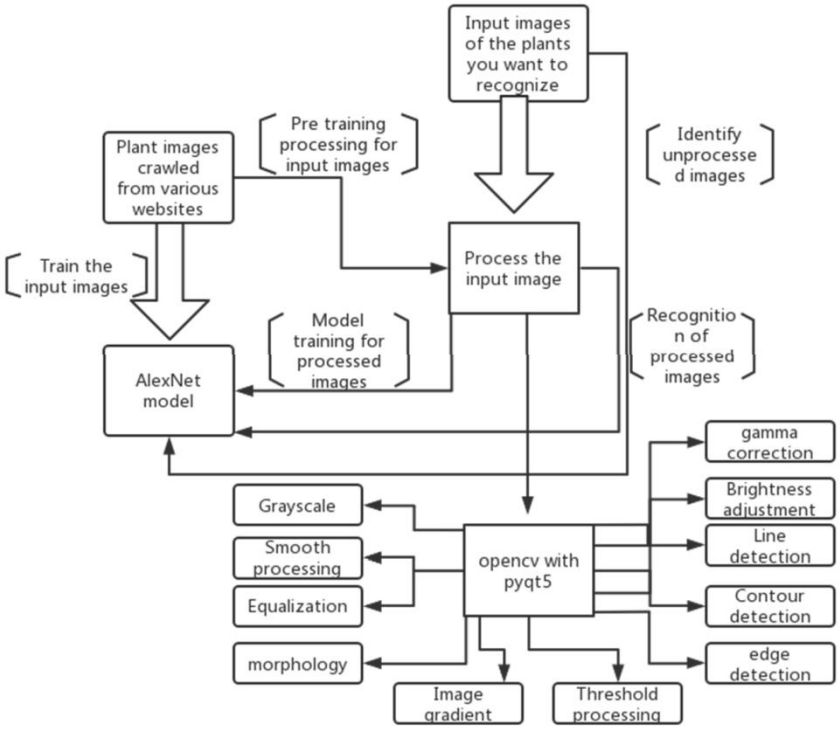

Figure 1. Basic process of image recognition

3. Image Processing based on That Implemented by Opencv and Pyqt5

Through opencv and pyqt 5, we implemented a function for image processing. Pyqt is a GUI widget kit. For this experimental environment, we configured:

3.1 Experimental Environment:

3.1.1. pytorch-1.6.0

3.1.2. python-3.7.9

3.1.3. window-10

3.1.4. pycharm

3.1.5. pyqt5(Corresponding QT Designer and toolkit)

By making a simple interface model, we have implemented the following functions

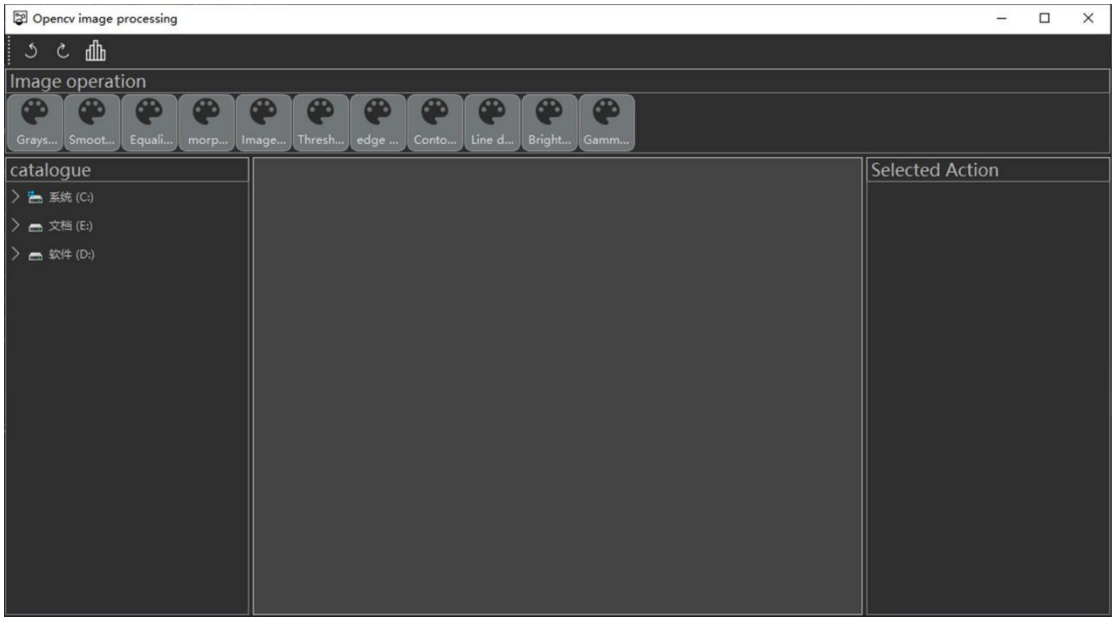

Figure 2. A simple interface model

For the picture can be performed in graying, smooth processing, equalization, morphology, image gradient, threshold processing, edge detection, contour detection, line detection, brightness adjustment, gamma correction, etc.

4. The Images are Trained and Recognized based on the AlexNet Model in CNN

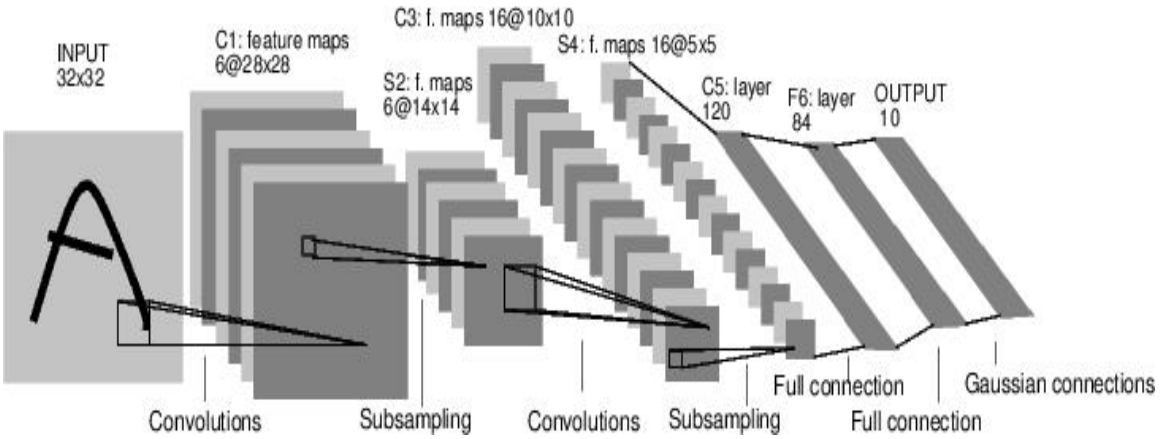

Figure 3. AlexNet model in CNN

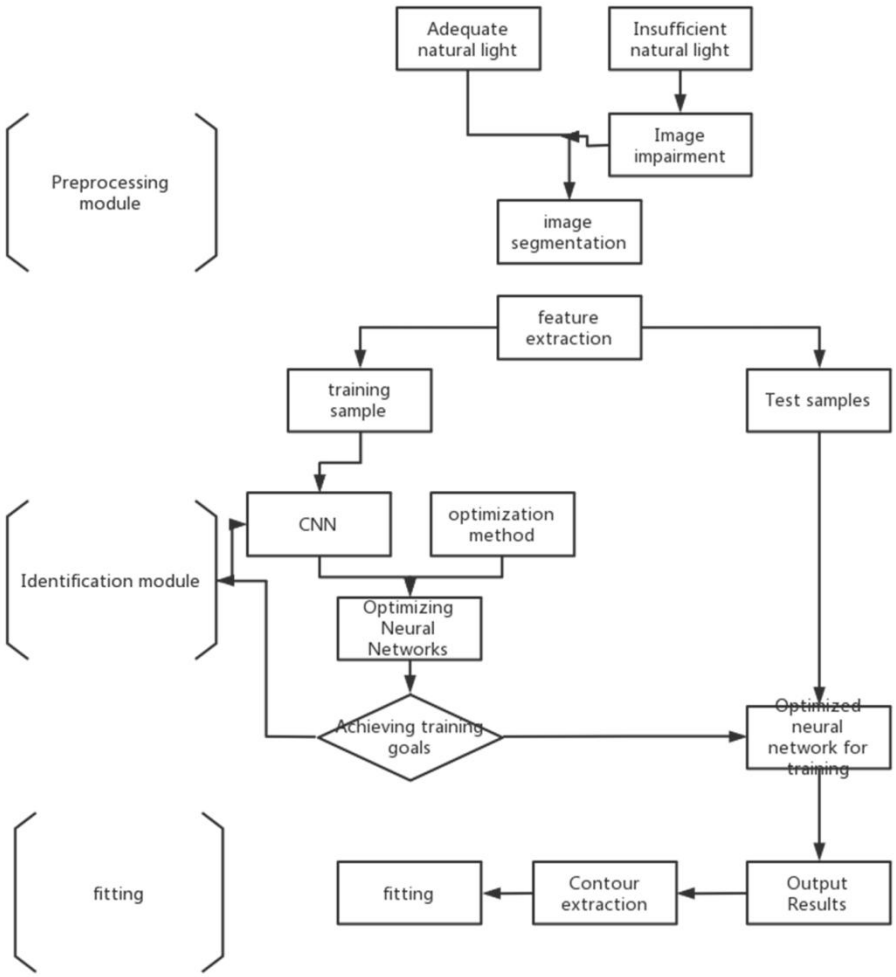

Figure 4. Process

4.1 In the Convolution Layer and the Sampling Layer, the Working Signal is the Positive Propagation [6]

During convolution and downsampling, it is divided into working signal positive image propagation and error signal back propagation. In the forward propagation direction of the working signal, each convolutional layer will be downsampled, and the input of the convolutional layer can be the initial image or multiple feature maps Maps. In the convolutional layer, because there are multiple convolution kernels, the current convolutional layer will output multiple feature maps.

$$Y_{i,j,k} = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} X_{i+m,j+n} \cdot K_{m,n,k} + b_k$$

Figure 5. Formula

4.2 Model Updates based on Transfer Learning Techniques

In order to adapt to the increasing number of plant species, an extensible model updating machine based on transfer learning technology is adopted. When facing a new task, the update steps are as follows: [7]

The pre-trained model is used to initialize the weights of the first four convolutional layers of the new classification model, which avoids the repeated training of features while retaining a large amount of improvement space of the model.

The labeled training set in the new task is sent to the classification model with existing initialized weights for training. The training process is the same as the pre-training model. Ready-the-shelf features pre-trained on the convolutional neural network of pre-trained models can be used to train new models. By keeping the pre-trained parameters fixed, or adjusting with a small learning rate, the new model does not forget the previously learned knowledge, while modifying the weight of the last layer Softmax to update the results of the classification.

After the training of the new classifier model, the classifiable target contains not only the currently trained category, but also the category in the prediction model.

4.3 Plant Recognition Algorithm based on the AlexNet Model [8]

The figure shows the principle of the plant recognition algorithm based on the AlexNet model, which is mainly divided into three parts: pre-training model, training model, and model test. In the pre-training stage, using the source training set, train the convolutional neural network model through AlexNet network, the classifier can be used to test the source test set, the training model stage, when a new training set appears, the classification model generated by the pre-training stage will pre-training model to initialize the new classifier training, the source test set and the new test set and updated to test the newly generated classifier. The training and testing stage in the algorithm use GPU parallelization acceleration, which improves the efficiency of model training and testing.

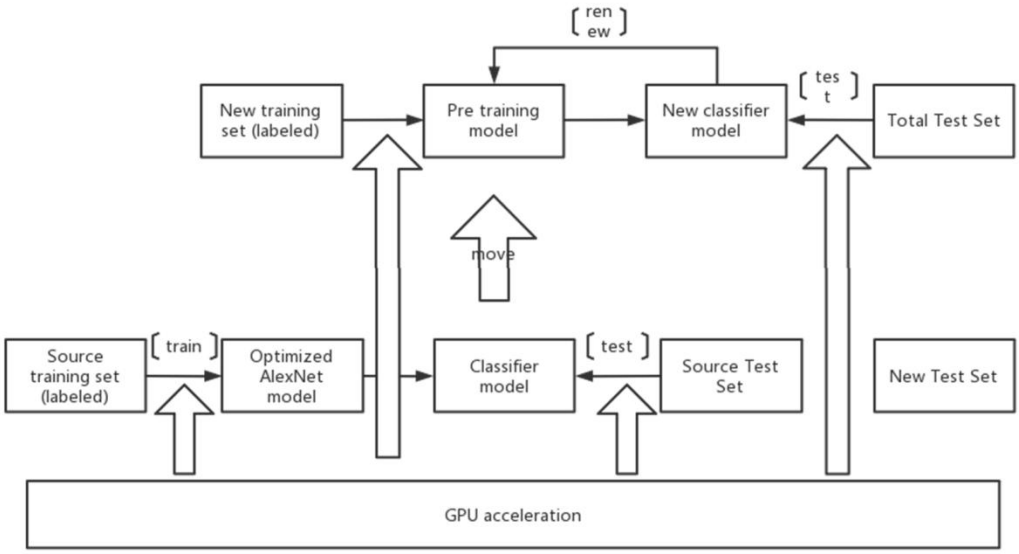

Figure 6. Model training and testing

5. Experiments as Well as the Results

Pre-processing phase of the pictures.

The model to realize the plant image recognition process includes: first we test personnel in pc to upload a good or climb from the Internet to a kind of plant image, after the implementation of image processing, we will enter the image into trained AlexNet model, began to identify the input images, and then according to the model training good plant species, and then the largest probability of plant input to the gui small program interface and return to the probability of the plant, the user can view the detailed information of the plant in the production GUI interface.

Figure 7. Picture

Figure 8. Processed image

Results prediction analysis Fig.

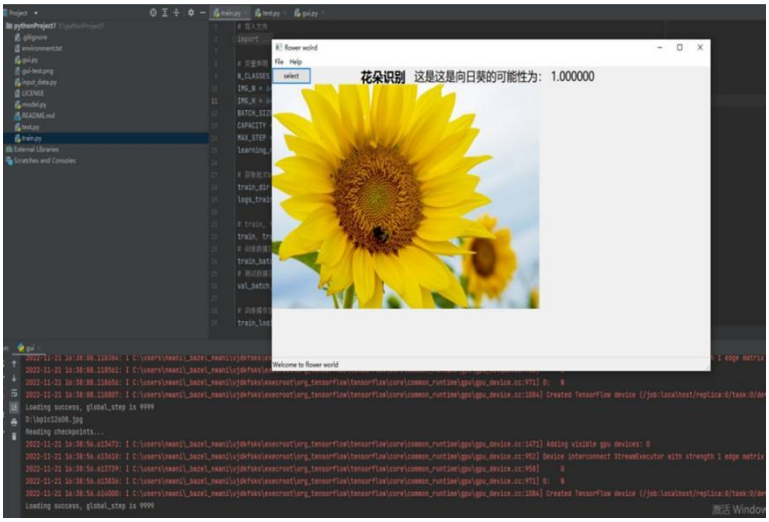

Figure 9. Recognized image sunflower

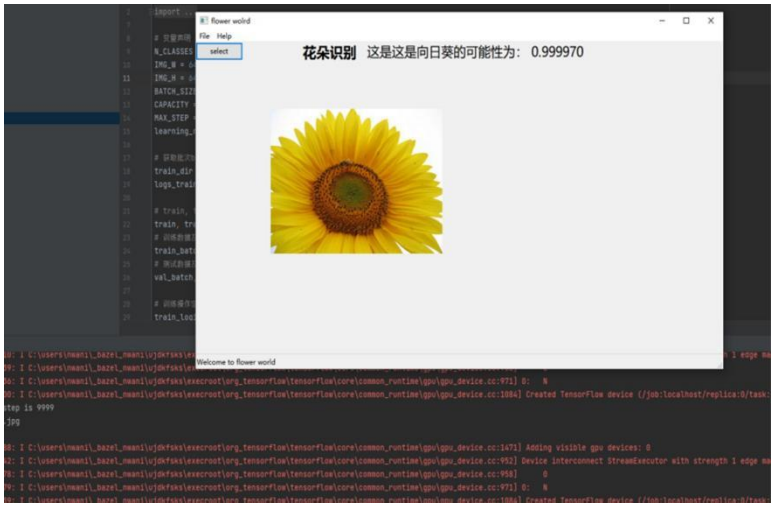

Figure 10. Recognized image sunflower

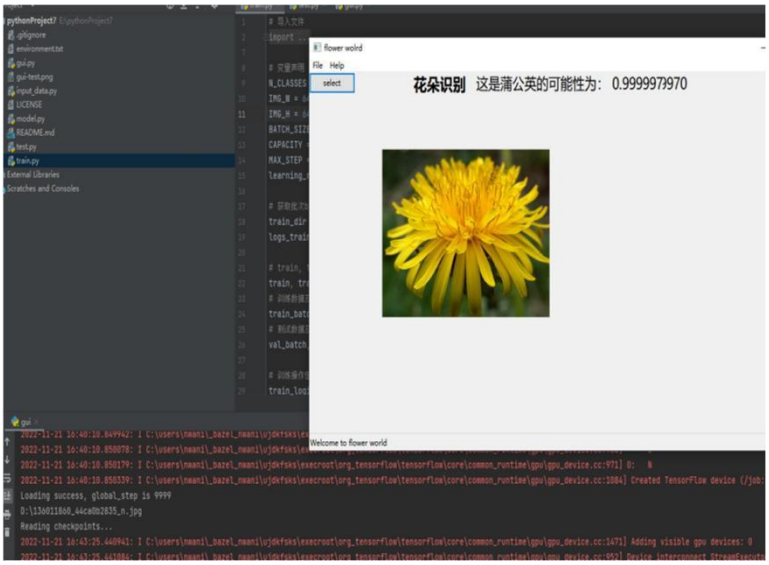

Figure 11. Recognized image tulip

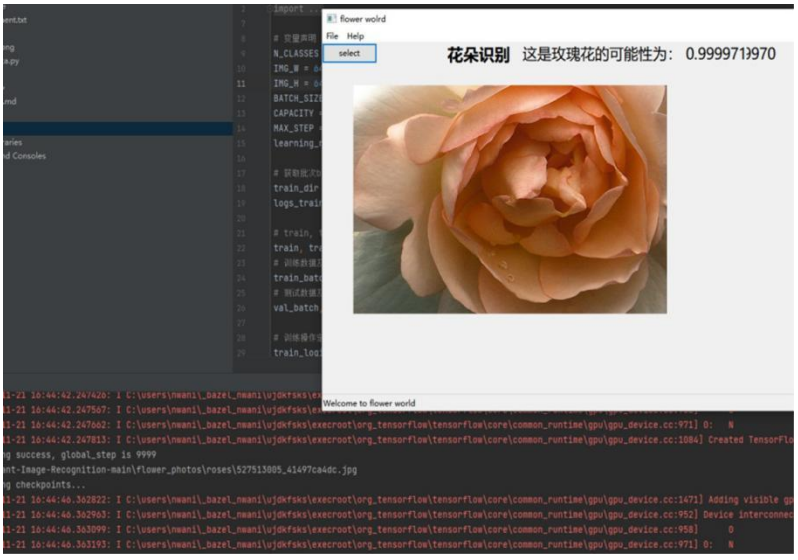

Figure 12. Recognized image rose

6. Conclusion

This paper for plant image recognition, combined with convolution neural network and CPU calculation, put forward with opencv and pyqt 5 implementation after image processing of image training of deep learning model, after our repeated experiments, considering several necessary factors similar to the picture is not clear, pictures in a stain, and identify the object of the main body, etc., also consider several potential factors, similar to the flower situation, petals and plant leaves incomplete draw the following conclusions:

1. Compared with the traditional cnn model, for the convolution layer and increase node neurons, the introduction of deformable convolution, the loss function to the classification function layer, can improve the generalization performance of the cnn model, after pictures of Gaussian filter processing, noise elimination and edge processing, improve the efficiency of the model algorithm, better difference between the different kinds of plants.

2. In this process, we used the AlexNet model as our training image model to achieve good results, And combined with the plant data map for crawling from various websites, After marking the pictures, partition, The datasets were then formed for testing, In contrast to the initial cnn underlying model, We added the convolution layer with the pooling layer, The improved model has a significant improvement in both the model loss rate and the number of training iterations, Where the recognition accuracy of the specific ten trained flowers is above 98%, Compared to the original simple cnn model, Our recognition accuracy and operation rate and so on have been greatly improved.

3. In this experiment, our final results are relatively matched with the expected results. The improved AlexNet model can be trained to identify more images. Compared with the previous rate and accuracy, it is also greatly improved and has a very good effect.

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