Health Detection for Potato Leaf with Convolutional Neural Network

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***Abstract*—Potato is the fourth largest food crop in the world and grown in many places of the world. Potato crops mainly infected with fungi, and hence they got early blight diseases and late blight diseases. Real time control of disease and management can effectively increase production and reduce farmers' losses. The ability can identify infected crops automatically for farmers. Therefore, this paper proposes a CNN (Convolutional Neural Network) architecture which is suitable for potato disease detection. At first, we will create a database for our training set by means of image processing in the CNN. Adam is used as the optimizer, and cross entropy is used as the model analysis basis. Softmax is used as the final judgment function. The convolution layer and resources are minimized usage amount while maintaining high accuracy. The experimental results show that the parameter usage is 10,089,219 and the accuracy of the disease judgment can reach 99% under the preset model which is proposed in this paper.**

Keywords— convolutional neural network (CNN), disease detection

I. Introduction

Modern agriculture is not just an industry. With urban development, it is a common problem in the world to be able to feed a growing population with limited land. However, plant diseases have greatly affected the production of our crops and caused major economic losses in agriculture. The potato is one of the most consumed crops in the world. Early blight and late blight are the most common diseases of potatoes.

Related research in recent years, image processing techniques are widely used in agriculture, segmenting images, and use SVM (Support Vector Machines) to train detection methods [1]. R. Kaur and SS Kang [2] used. SIFT (Scale- Invariant feature transform) and K-means and SVM to detect the proportion of leaves on plants and Classification for SVM blade types [3]. Most of the literature uses SVM as the core of judgment. However, due to advances in process technology, the artificial neural network has been gradually taken seriously. We use the Convolutional Neural Network (CNN) in the artificial neural network to judge the symptoms of plant leaves, thereby achieving an intelligent detection system.

II. System Architecture

Deep learning is a machine learning algorithm. Each layer is closely related. The output of the previous layer will be used as the input of the next layer. The process of learning can be unsupervised, supervised or semi-supervised. Deep learning does not need to specifically mark features, and then extract features. When training the model, the model will automatically extract features, optimize the learning algorithm, and the matching data is more important. In areas such as image processing, image restoration, speech recognition, deep learning is used in many studies.

In the experiment of judging plant diseases, Convolutional Neural Network (CNN) is a suitable learning method in deep learning. The CNN can accurately identify images and classification objects. The CNN is mainly composed of four layers, as shown in Fig. 1 which are a convolution layer, a pooling layer, an activation function layer and a full connection layer.

A. Early Blight and Late Blight of Potato

When the potato leave infected with early blight, then the lesions will appear dark brown to grayish white. The shape is approximately circular, and the lesion becomes enlarged until the veins become irregular.

If the potato leaves infected with late blight, the spots are on the sharp corners of the leaves and the leaves. The CNN model is trained with different potato conditions and healthy leaves, and there are three different categories: The Fig. 2 is shown the healthy potato leaves, the Fig. 3 is shown the potato leaves which is infected with early blight, and the Fig. 4 is shown that the potato leaves is infected with late blight.

B. Image Processing

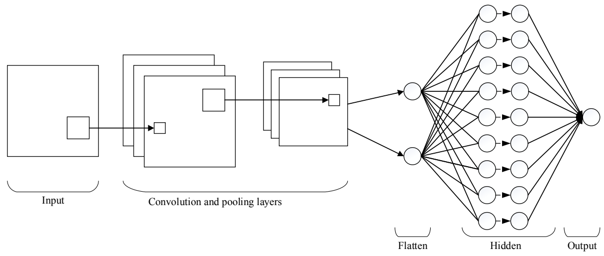

Fig. 1. The proposed system architecture.

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Fig. 2. Healthy potato leaves.

Fig. 3. Early blight potato leaves.

Fig. 4. Late blight potato leaves.

In order to make the picture training based on the color, the image preprocessing is performed without letting other colors interfere.

First enter the picture, then use Gaussian filtering to remove the noise, normalize the picture to reduce the influence of the light, then use the formula to extract the desired area, remove the scattered picture points, and finally restore the reconstructed picture.

Fig. 5, Fig. 7 and Fig. 9 are an original picture of a potato leaf. In order to remove the picture noise to achieve a better effect on the processing of the picture. Since σ is too large, the picture is too blurred, and σ=0.8 has achieved edge smoothing effect. Finally, we choose Gaussian version for 7*7 and standard deviation of 0.8 for Gaussian filtering shown in Fig. 6.

C. Picture Normalization

The RGB color model is a commonly used format in image processing, but the disadvantage is that it is susceptible to changes in light and shadows.

Fig. 5. Potato (original)

Fig. 6. Potato (7*7 Gaussian yields， σ =0.8)

Fig. 7. Potato leave (original picture)

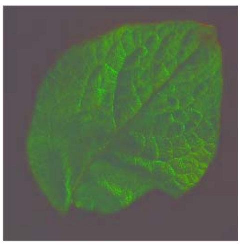

Fig. 8. Potato leaves (after normalization)

Fig. 9. Potato leave (original picture)

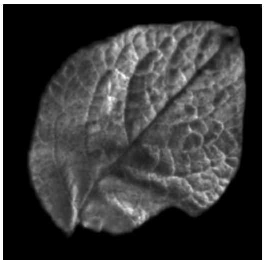

Fig.10. Potato leaves (after green fortification)

Fig. 11. Processed potato leaf image

Therefore, during the processing of the image, RGB is normalized to eliminate the effects of illumination. RGB normalization is shown in the Equation (1). In the RGB normalization process, the shadow at the edge of the leaf also disappears as shown in Fig. 8.

$$R' = \frac{R}{R+G+B} . G' = \frac{G}{R+G+B} . B' = \frac{B}{R+G+B} \tag{1}$$

D. Region of Interest

As long as your green color is more than red or blue, the value of RGB will definitely be greater than 0.

So the value of the green area will be greater than 0, thus taking the green part. As shown in Fig. 10, the parts other than green turn black.

E. Color Conversion

Make the picture open and closed to remove the surrounding noise. Restore the image to the original image, use Fig. 7 as the material to reconstruct, as shown in Fig.11.

F. Convolutional Layer Scanning

As shown in Fig. 12, the black dots are one pixel at a time. If we use a 3*3 filter, after convolution, the filter takes the nine largest pixels out of the largest feature and combines them into a new pixel.

The filter begins to move the scan step by step and repeats this step until the end. The new matrix that is smaller than the input image size is generated.

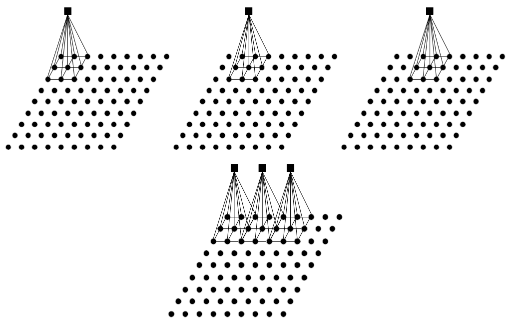

Fig. 12. Filter scan

TABLE I. COMPARISON OF THIS MODEL WITH OTHER MODELS

Model	Trained accuracy	The number of parameters	Reduced
VGG16	98.15%	138,357,544	99.07%
VGG19	48.55%	143,667,240	99.72%
New proposed	99.53%	10,089,219	

G. Activation Function of convolutional Neural Network

ReLU has become the most popular activation function in recent years. It is a hybrid identity function and a threshold activation function. The biggest advantage is that it can avoid the problem of gradient disappearing. This paper deals with image recognition. This article deals with the problem of image recognition and avoiding the disappearance of gradients. The parameter of $f(a)$ stands for activation function and can solve nonlinear problems with neural networks. The equation (2) of a is the value of the -------

neural network node. In equation (3), $W_{i,j}$ is weight, b_j is the bias value, x_j is x the j pixel value.

$$f(a) = \begin{cases} a, a \geq 0 \\ 0, a < 0 \end{cases} \quad (2)$$

$$a_i = \sum_j W_{i,j} x_j + b_i \quad (3)$$

H. Integrate with Side Mirror System

A Softmax [4] function is a decision function for potato leaf disease. In this paper, we use the Softmax function as a decision. The result of our classification is whether the plant is sick, whether the plant is healthy, whether the target plant is judged, and the disease is healthy. It cannot coexist with each other, so the Softmax function is used. If you want to be able to use complex numbers in decision making, you can consider using the Logistic function as a decision function.

The Softmax function is given by Equation (4). All values are between 0 and 1, which is consistent with our probability. The number of K is final output. The Equation (4) of a is the value of the neural network node. σ represents the value of Softmax.

$$\sigma(a)_i = \frac{e^{a_i}}{\sum_j e^{a_i}}, i = 1, \dots, K \quad (4)$$

I. Pooling Layer

Pooling is the process of reducing the input of a zone to a single value. In convolutional neural networks, this information set provides information similar to the output connection while reducing memory consumption.

For example, the maximum pooling is to divide the image into several square blocks and extract the maximum value of the output for all the blocks. The largest feature of the pooled layer removal area will reduce the size of the data each time.

Pooling provides basic invariance for rotation and translation, and improves object detection for convolutional networks.

III. EXPERIMENTAL RESULT

Comparison of the model of this paper with other models for disease detection in the potato industry is shown in Table.1. According to the VGG19 model, although the accuracy of the prediction is the highest, the accuracy of the subsequent evaluation does not increase any more. The accuracy of the VGG16 training is greatly increased, but the convergence and speed are compared with the paper. Nothing is faster. Although the initial prediction accuracy of this paper differs a little between VGG16 and VGG19, the subsequent increase in prediction is significantly higher than that of VGG16 and VGG19. Moreover, the amount of parameters used in this paper is significantly less than that of VGG16 and VGG19. The proposed method have lower parameter quantity, faster calculation and less the use of resources.

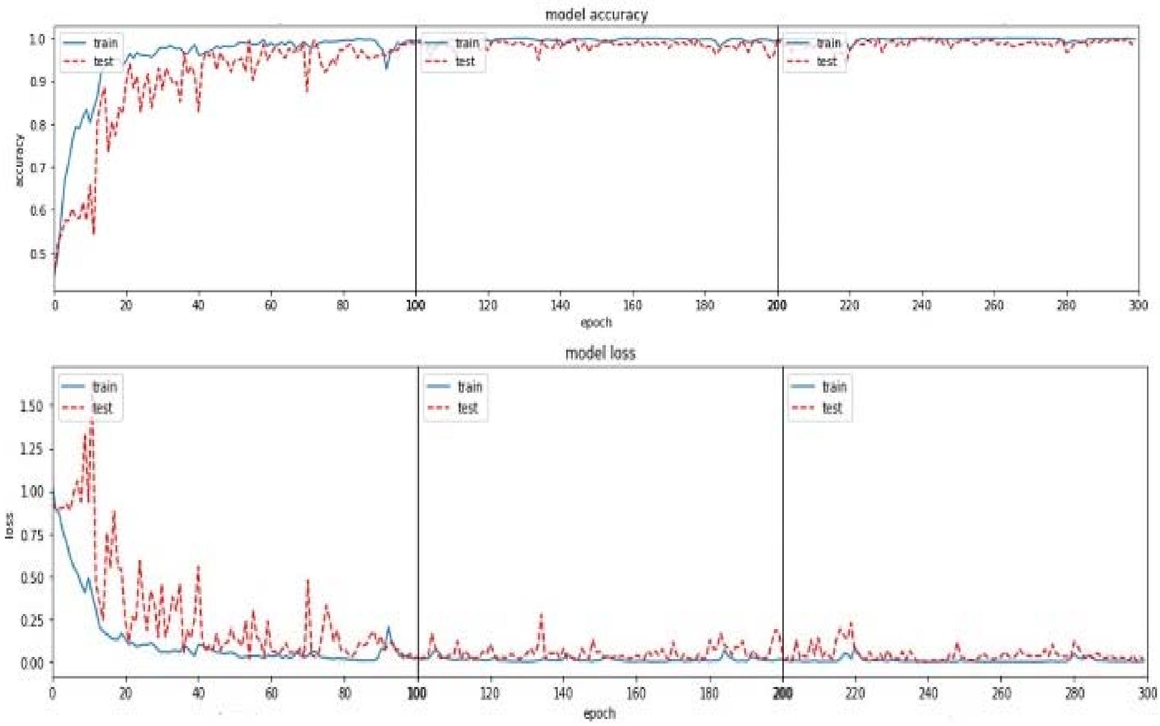

Fig. 13. The loss rate of the training set of potato leaves

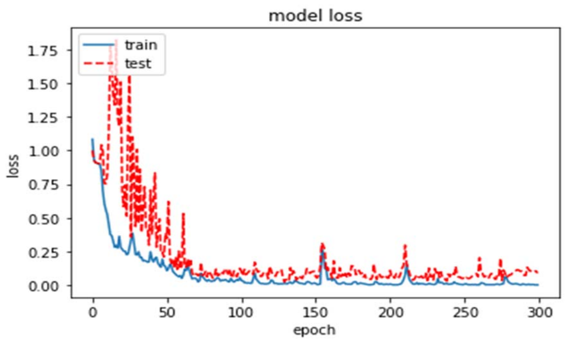

Fig. 14. Model A LOSS curve

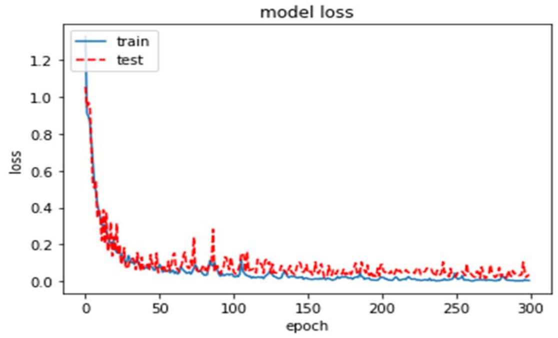

Fig. 15. Model B LOSS curve

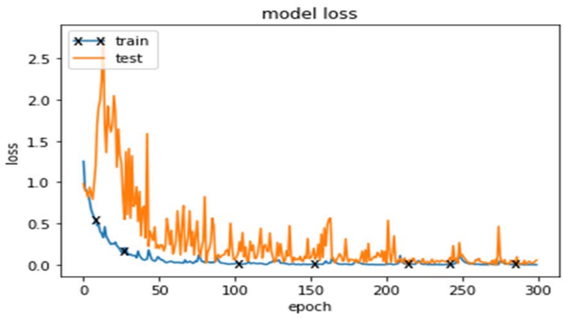

Fig.16. Model C LOSS curve

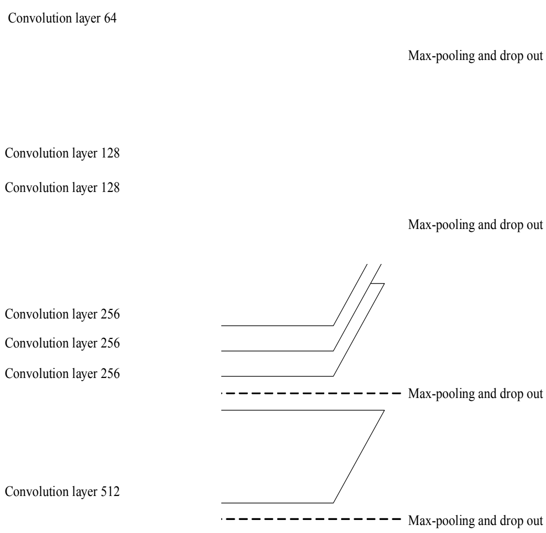

Fig.17. Convolutional neural network learning module

A. Decision Equation of Potato Leaf Early Blight and Late Blight on CNN

We choose to use cross entropy as equation (5) as our loss rate function, where the number of samples is n and z is the number of labels. Cross entropy has an outstanding performance in classification, but cross-entropy has another feature, that is, in the role function, the Softmax function must be used as the decision function.

The value of $y_{i,t}$ is the output of Softmax. The smaller the difference between the prediction and the actual, the lower the value of LOSS.

$$LOSS = -\sum_{i=1}^{n}\sum_{t=1}^{z}(y_{i,t} * \log(y_{i,t})) \quad (5)$$

B. The Wisdom Judgment of Potato Leaf Early Blight and Late Blight

The initial training curve for LOSS is very unstable as shown in Fig. 13. In the case of a large shock, when the training was 100 times, the training curve gradually became stable, but there was still no convergence. Therefore, the situation is strengthened to 300 times. As can be seen from the graph, the number of trainings is gradually stabilized after about 200 times, and the line gradually converges, and there is no overfitting.

C. Model Architecture and Accuracy Comparison

In this paper, the three models A, B and C are used as reference to compare the architecture, and try to find a model suitable for judging potato disease.

The three models A, B, and C are used with different depths and widths. The depth of model A is the deepest, and the depth of model B is the shallowest. Try to find the depth of the model that matches the data.

A graph of the loss of the model A is shown in Fig. 14. There is a slight overfitting in the case of about 75 times of training. Therefore, the model depth may be too large.

Fig. 15 is a graph of the loss of the model B. The curve is gradually stabilized after about 50 training times, and the accuracy is only maintained at a certain value, which is a model that can be used.

Fig. 16 is a graph of the loss of the model C. The curve is gradually stable after about 150 training times, and the accuracy is large only maintains a certain value, and is a model that can be used.

Compare the three models from A, B and C. The model A is obviously too deep and not suitable. Model B is more accurate than the model C.

From the model C to get the highest accuracy and the lowest loss rate, we propose a framework for the paper using the model C.

D. The Proposed System

We propose a CNN configuration suitable for blade detection as shown in Fig. 17. The types and quantities of the materials in this proposed system are not enough. Therefore, the model reduces the number of nodes before and after the model, and the middle part is maintained, which can reduce the occurrence of overfitting and speed up the training because resource parameter usage is reduced. In the part of the pooling layer, we add drop out part. This is not necessarily necessary, but it is helpful to prevent overfitting. Ideally, this model is only needed.

Without overfitting, we can train until the loss rate loss is reduced until the accuracy reaches 100%, but the reality is that it is impossible to stabilize the accuracy rate to 100%. In reality, there will be prone to overfitting. Therefore, let the model increase in the number of trainings, and then increase with the increase in the number of trainings, and the maximum level of maintenance is our goal.

IV. Conclusion

The proposed method for detecting the health status of potato leaves is realized by the structure of convolutional neural network in the automatic judgment of crop diseases. Through the possession of a large number of image databases, and then image processing, a good database is established to improve the accuracy of the convolutional neural network. This paper proposes a model that uses resources for a small convolutional neural network. It is more suitable for the architecture used in judging plant diseases, under the image database of more than 2,000, and the use of smaller resources. The accuracy of the disease judgment can also achieve 99% accuracy.

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