Research on Integrated Algorithm Based on Convolutional Neural Network for Rice Disease Identification

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Abstract. Rice is the staple food in many Asian countries. The effective intelligent identification of rice diseases is helpful to improve the industrialized management of rice, reduce the input of manpower and improve the efficiency. In 2018, China's first intelligent identification and service system for rice pests and diseases was released, but its average identification rate is only 80%. This paper takes 4 diseases of rice as the research object, adopts supervised learning, uses convolutional neural network to extract the characteristics of each disease, and integrates the extracted characteristics with AdaBoost algorithm to improve the accuracy. According to the research quantity and the characteristics of the research object, a 10-layer convolutional neural network and three convolution kernels are designed to miss the important information of the image as much as possible. According to the method in this paper, the correct recognition rate of the four diseases of Bacterial Blight, Flax Spot, Sheath Blight and Leaf Sheath Spot was 95.64% on average, which is higher than 5.56% and 14.69% respectively when the convolution neural network and AdaBoost algorithm are stable. Therefore, compared with the classical convolutional neural network and AdaBoost, the integrated algorithm of convolutional neural network proposed in this paper has a higher accuracy in rice disease research.

1. Introduction
Rice is the staple food of many Asian countries. Asia's rice planting area accounts for 90% of the world's, while China's rice planting area ranks second in the world. Rice accounts for 60% of Chinese people’s rations. The demand for grain is huge, but the cultivated land area is limited. The cultivated land area that can be used to grow rice is gradually shrinking. In addition to the complexity of rice suffering from diseases and insect pests, it has become a necessary task for rice planting to improve the yield of rice. In this paper, an integrated algorithm based on convolutional neural network is proposed. Experiments show that this method is more accurate than the convolutional neural network alone.

2. Convolutional Neural Network
Convolutional neural networks (CNN) is a kind of feedforward neural networks with convolution computation and depth structure. It is one of the representative algorithms of deep learning. Convolutional neural network has the ability of representation learning, which can classify input information according to its hierarchical structure, so it is also called shift invariant artificial neural network (Sian). The research of convolutional neural network began in the 1980s and 1990s. Time delay network and lenet-5 are the earliest convolutional neural networks. After the 21st century, with the advance of deep learning theory and the improvement of numerical computing equipment, convolutional neural network has been developed rapidly and applied in computer vision, natural
language processing and other fields. Convolutional neural network imitates the visual perception mechanism of biology, which can be used for supervised learning and unsupervised learning. The sharing of convolutional kernel parameters in the hidden layer and the sparsity of interlayer connections make the convolutional neural network be able to grid like with less computation (Topology) features, such as pixel and audio learning, have stable effects and no additional feature engineering requirements for data. As a kind of deep learning network architecture, convolutional neural network can effectively reduce the complexity of the network, reduce the number of training parameters, make the model invariant to translation, distortion and scaling to a certain extent, and has a strong fault-tolerant ability, so it is easy to train and optimize the network structure. With the development of labeled data and GPU, convolutional neural network research has emerged and achieved first-class results. Liu Tingting, Wang Ting and Hu Lin found that the recognition rate of convolution neural network to rice sheath blight reached 97%, which was better than 95% of SVM [1]. Duan Lingfeng and other four people found that the full convolution neural network was superior to the existing crop ear segmentation algorithm when they segmented the big field rice ear [2]. The experimental results of Huang Shuangping and four people show that the deep convolution model established by Google net can well realize the accurate detection of rice ear blast disease [3].

3. Boosting and Adaboost

The current integration methods mainly include bagging [4] and boosting [5] algorithms. The main reason why the enhanced algorithm is chosen in this paper is that in the past ten years, the integrated algorithm has shown very excellent results.

Bagging algorithm, also known as bagging algorithm, is a group learning algorithm in the field of machine learning. Originally proposed by Leo Breiman in 1996. Bagging algorithm can be combined with other classification and regression algorithms to improve its accuracy and stability. At the same time, it can reduce the variance of the results and avoid the occurrence of over fitting. Bagging is a technique to reduce generalization error by combining several models. The main idea is to train several different models separately, and then let all models vote on the output of test samples. This is an example of a conventional strategy in machine learning, known as model averaging. The technology that uses this strategy is called the integration approach.

The reason model averaging works is that different models usually don't produce exactly the same error on the test set. Model averaging is a very powerful and reliable method to reduce generalization error. As the benchmark of scientific paper algorithm, it is usually not encouraged to use, because any machine learning algorithm can greatly benefit from the model average (at the cost of increasing calculation and storage).

Boosting is a common integrated learning method, which is widely used and effective. In the classification problem, it learns multiple classifiers by changing the weight of training samples, and combines these classifiers linearly to improve the performance of classification [6]. In this paper, a representative method belonging to boosting cluster is selected, AdaBoost [7].
Table 1. AdaBoost Algorithm

| No. | Step | Description |
|-----|------|-------------|
| 1   | Initialize the weight distribution of training samples: \( D_1(x) = \frac{1}{n} \) |
| 2   | for \( t = 1,2\ldots T \): |
| 3   | The training data set with weight distribution \( D_t(x) \) is used for learning, and the weak classifier \( G_t(x) \) is obtained. |
| 4   | Estimate the classification error rate of \( G_t(x) \) on the training data set: \( \varepsilon_t \), (enter the next step when \( \varepsilon_t \) is less than 0.5, otherwise the loop ends (\( G_t(x) \neq f(x) \), where \( f(x) \) is the real function) |
| 5   | Calculate the weight of \( G_t(x) \): \( \alpha_t = \frac{1}{2} \ln \frac{1-\varepsilon_t}{\varepsilon_t} \) |
| 6   | The next weight distribution \( D_{t+1}(x) = \frac{D_t(x) \exp(-\alpha_t f(x) G_t(x))}{Z_t} \) (\( Z_t \) is the normalization factor) |
| 7   | Get the final classifier: \( \text{sign}(\sum_{t=1}^{T} \alpha_t G_t(x)) \) |

AdaBoost, as an iterative algorithm, is known as the "integration of ten lines", its simplicity and accuracy are recognized by everyone, so it has been successfully applied in many aspects [8]. The four Xu Zhu people applied AdaBoost algorithm to the fatigue driving detection system, and found that this method can resist the interference of the environment, and has good real-time performance [9]. Yang Xiaoqi compares the AdaBoost decision tree algorithm with the other five algorithms, and through the classification of acid volcanic rock lithology, finds that the AdaBoost algorithm optimized by parameters can achieve the recognition accuracy of more than 90% [10]. Zhou mengran si x people will use linear discriminant analysis (LDA) algorithm as a weak classifier, use AdaBoost algorithm to integrate the method to identify the fluorescence spectrum of mine water inrush source, and optimize this algorithm. The experimental results show that AdaBoost LDA Algorithm is feasible and effective for the discrimination and early warning of Mine Water Inrush Source [11]. In 2003, the author of AdaBoost won the Godel prize, which is enough to show the contribution of AdaBoost to various researches.

4. Experiment
In this experiment, the input image is \( 64 \times 64 \times 3 \), and the selected convolution kernel is three \( 5 \times 5 \times 3 \) convolution kernels (filters). When the first convolution is completed, three \( 60 \times 60 \) characteristic graphs are output.

The weight of convolution kernel of convolution neural network can be shared. One convolution kernel can get part of the features. In order to get more complete information, three convolution kernels are selected here. Each convolution kernel is used to learn different features of the image. After obtaining three characteristic images, tanh relu [17] is used to activate, and then enters the sampling layer. The sampling layer is also called the pooling layer. Because the dimension of the output characteristic graph is too large, in order to reduce the amount of data calculation, shorten the time and reduce the probability of over fitting, the maximum pooling is carried out in this layer, and the obtained characteristic graph is output. The convolution layer set up in this paper is 10. The training speed and accuracy are in a satisfactory state. After 10 times of convolution and pooling, a lot of small eigenvalues are obtained. These local eigenvalues need to be connected to map to the sample marker space.

This integrated model is the model of AdaBoost algorithm integrating convolutional neural network. The experimental steps are as follows:

1. The experimental data set is divided into training data and test data according to the ratio of 7:3. In order to ensure the accuracy of the test, the distribution of four diseases in the two kinds of data is the same.
(2) The weights of the data in the training set are initialized to ensure that the probability of each data is equal during the first sampling training.

(3) For the model, set 10 layers convolution neural network, 3 5 × 5 convolution kernels, step size is set to [1,1], the activation function uses tanh relu function, which can converge faster. The classification function uses softmax [20]. Adadelta is selected by the model network optimizer.

(4) In this network, four pooling layers (P) are designed, each of which takes 2 × 2 matrix.

(5) For each time the convolutional neural network softmax classification algorithm classifies the wrong images, update the weights of these images, increase the data weights of the classification errors, so that there is a greater chance to select the corresponding images for training in the next sampling.

$$D_{t+1}(x) = \frac{D_t(x) \exp(-\alpha_t f(x) G_t(x))}{Z_t}$$

(6) The trained weak classifier is combined linearly according to its accuracy to form a strong classifier.

$$\text{sign} \left( \sum_{t=1}^{T} \alpha_t g_t(x) \right)$$

The experimental results are as follows:

| Training model                          | Convolutional Neural Network |
|-----------------------------------------|-----------------------------|
| bacterial blight of rice                | 95.42%                      |
| Leaf spot of rice                       | 97.03%                      |
| rice sheath blight disease              | 96.21%                      |
| Leaf sheath reticulum spot of rice      | 93.88%                      |

The average recognition rate of the integrated algorithm of convolutional neural network and AdaBoost on the test set is 95.64%, and the highest recognition rate is 97.03%.

5. Summary
In this paper, the convolution neural network and AdaBoost algorithm are integrated to form a new algorithm. Experiments show that the algorithm has excellent recognition ability in rice bacterial blight, rice flax spot, rice sheath spot and rice sheath spot. The experimental results show that the highest accuracy of the algorithm is 97.03%, and the average recognition rate of the algorithm is 95.64%. The algorithm proposed in this paper is better than the traditional convolutional neural network with an average recognition rate of 90.08% and AdaBoost with an average recognition rate of 80.95%. At the same time, the loss function of the algorithm is stable at 0.31.

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