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Research on Identification Method of Red Date Grade Based on Deep Learning

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Abstract

Red dates need to be graded in the process of processing, so as to price according to quality, convenient for consumers to choose at the same time to speed up the circulation of goods, improve the added value of products. A deep learning based Stacking method for date classification was proposed. 21280 date images of 4 different grades of the same variety were collected for pre-processing and data set was established. A Stacking integrated learning model with three different convolutional neural networks (VGG16, ResNet 50, Densenet121) as the base learner and logistic regression as the secondary learner was constructed. The comparison between the integrated model and the single neural network model was conducted. The results show that the Stacking integration model proposed in this experiment can achieve 91.88% accuracy in jujube grading.

Keywords

Deep learning, Classification, Red jujube, Convolutional neural network, base learner.

1. Introduction

With its unique environmental and geographical conditions, Xinjiang has become one of the main jujube planting areas in China. Red date processing plants need classification when they purchase red dates from farmers for processing. At present, most of them are classified by mechanical method, which is difficult to ensure comprehensive quality [1]. Therefore, a reliable method with high classification accuracy is needed to replace mechanical method for classification of red dates.

In recent years, computer vision technology, artificial neural network and machine learning have been popularized and successfully applied in many fields such as medicine, transportation and shopping [2]. Scholars have also applied it to the classification and classification of fruit seeds. Computer vision technology has the advantages of real-time, objective and non-destructive classification, mainly through the characteristics of fruit color, texture, shape and external defects, etc. [3]. At present, hyperspectral imaging, intelligent sensory technology and machine learning methods are mainly used to detect and classify fruit quality at home and abroad [4, 5]. Wang Hongjun et al. [6] used machine vision technology to build an image acquisition system that could simultaneously obtain the three-sided projection of potatoes, obtain various characteristic parameters of potatoes, and establish a potato classification prediction model through multivariate data regression analysis. Su Jun et al. [7] proposed a classification method for dried red dates based on genetic algorithm optimized support Vector Machine (GA-SVM). Momin et al. [8] proposed an image processing algorithm combining binarization, morphological analysis and median filtering to classify mango quality grades.

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2. Materials and Methods

2.1 Model introduction

Artificial neural network is a kind of mathematical model simulated under the inspiration of biological neural network. Convolutional neural network is a kind of feedforward neural network with a certain depth structure and is one of the representative algorithms of deep learning [9-11]. It extracts features through convolution calculation and retains useful information [12]. Compared with traditional methods, neural network is more precise and accurate in image feature extraction. At present, mainstream convolutional neural networks include Lenet-5 [13], VGG, AlexNet, GoogLeNet, ResNet, Densenet et al. [14].

Stacking method was first proposed by WOLPERT [15] and has been popular in various data mining competitions [16]. Stacking method consists of base and secondary learners and is widely used in education, medicine, social sciences, etc., but less in agriculture [17].

The Stacking method is implemented as follows: the original data set is divided into training set A and test set B, the original training set A is divided into K folds, wherein the K-1 fold is denoted as the base learner training set and the remaining fold is denoted as the verification set and is denoted as D. Cross-validation is carried out, that is, the stable model is obtained by training data set C first, and then the model is used to predict D.

2.2 Experimental materials

The grey dates of preliminary processing were purchased from the first Division of Alar city and divided into four grades, namely, super grade, First grade, second grade and third grade. Preliminary manual selection was carried out to remove the defective red dates, such as worm fruit, damage and dry strips, for image collection.

2.3 Experimental platform

The main computer hardware configuration used in this experiment is: Intel Core I7-7700 quad-core CPU, frequency 3.6ghz, quad-core eight threads; 16GB DDR4 memory, with a frequency of 2,666mhz; It runs Windows 10 (64-bit). The software used mainly includes OpenCV image processing software, Pytorch deep learning framework, Jupyter compilation software, Anaconda virtual environment and CPU computing.

2.4 Experimental data set

2.4.1 Data set construction

The construction process of date dataset is as follows:

(1) Original image collection. The camera was placed at a fixed height with a bracket, the focal length was adjusted, and the dates of different grades mentioned above were placed in the white background frame in turn to obtain the original images of dates.

(2) Image cutting. The original image was imported into the computer, and the Opencv software was used for orthodontic and clipping processing. The original image was clipped into a single red date RGB image and named in order.

(3) Manual annotation and data set establishment. The name, grade and other information of each picture were manually marked to establish date data set.

2.4.2 Data Preprocessing

The convolutional neural network uses a kernel size of 7×7. In order to ensure the level of information abstraction and extract the required features, it is necessary to unify the size of jujube images. Based on previous studies and repeated debugging, the best model effect is achieved when the image size is set to 224*224 pixels, and the offline data enhancement operation is adopted. So that the network can better extract features and increase the accuracy of the model [18].

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(a) original pictures of red dates (b) orthodontic images

(c) single red date after cutting (d) form the data sets

Figure 1. Image processing and data set establishment

This dataset contains 21 280 pictures of 4 different varieties of jujube. There were 17 024 images in training set and 4 256 images in test set.

2.5 Experimental methods

In this experiment, VGG16, ResNet50 and DenseNet121 were used as the base learner of the Stacking integrated learning framework. Meanwhile, these three neural networks were trained and predicted as independent single models respectively. The results of the Stacking integration model were compared with the prediction results of the Stacking fusion model to verify the effectiveness of the integrated model.

2.6 Model training

The main purpose of neural network is to extract the representative feature vectors that can distinguish the grades of red dates from the input pictures and classify the pictures based on different features. Neural network is used to train the date image dataset by iterative method. In order to ensure the reliability of the results, the codes used in this experiment were all taken from the author's official codes, and the same hyperparameters were set: IMAGE_SIZE is 224×224 pixels, BATCH_SIZE is 32 for each batch of iteration. Sigmoid function (Formula 1) is used as activation function, and stochastic gradient descent (Formula 2) is used as network optimization method.

$$S(x) = \frac{1}{1+e^{-x}} \tag{1}$$

$$x_{t+1} = x_t - \eta_t \nabla f_i(x) \tag{2}$$

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In this experiment, dynamic learning rate was used for parameter optimization. Every time the neural network completed all the training set, which was called an epoch, a network model was generated. When the network converges and the accuracy rate and loss value of network identification and classification basically remain stable, the training was stopped and the training model was saved. Three stable models of VGG16, ResNet 50 and DenseNet 121 can be obtained through training.

2.7 Evaluation indicators

In the process of red jujube grading identification, the input of neural network model each image only represent a certain level of red jujube, independent among red jujube grade and mutually exclusive, so using cross entropy loss function as evaluation index, the function is used for classification problems, said the actual output probability and expected output probability distribution distance [19], the closer the two probability distribution, The smaller the value is.

$$L = -\frac{1}{N}\sum_{i=1}^{N}\log\hat{y}_{(y^i)}^{(i)} \tag{3}$$

In the formula, N is the total number of categories, $\hat{y}^{(i)}$ represents the predicted probability distribution, and $y^{(i)}$ represents the real label probability distribution.

3. Results and Analysis

The model training and prediction in this experiment were all completed under the Pytorch deep learning framework, using the same data set and unified hyperparameters. The training results of VGG16, ResNet 50 and DenseNet 121 models are shown in Figure 2 and Figure 3 respectively.

It can be seen that with the increase of training batches (EPOCH), the accuracy of the model gradually increased and the error continuously decreased. In the first 15 rounds of iteration training, the loss value and accuracy rate changed the fastest, and after the 25th round of iteration, the trend of change gradually slowed down and became stable. During the training, the change of DenseNet 121 was always more stable than that of ResNet 50. Finally, the accuracy of VGG16, ResNet50 and DenseNet121 on the training set was stable at 83.8%, 85.9% and 86.3%, respectively.

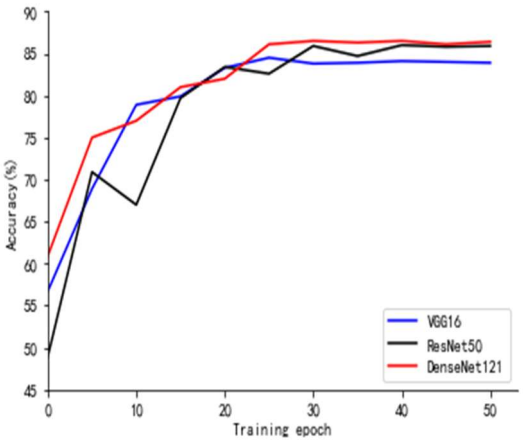

Figure 2. Accuracy changes of three different models on the training set

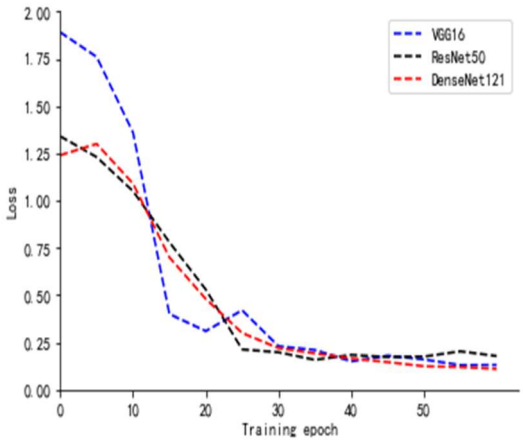

Figure 3. Loss changes of three different models on the training set

Figure 4 shows the changes of accuracy of the three models in the test set. It can be seen that the classification accuracy of the three models in the test set is better than their performance in the training set. VGG16 reached 84.57%, which was the lowest among the three models. The accuracy difference between ResNet50 and DenseNet121 is only 0.53 percentage points, which is because the increase of network layers cannot directly promote the improvement of accuracy. Too many parameters in the network will cause the model learning to stagnate over time, and the accuracy cannot be further improved.

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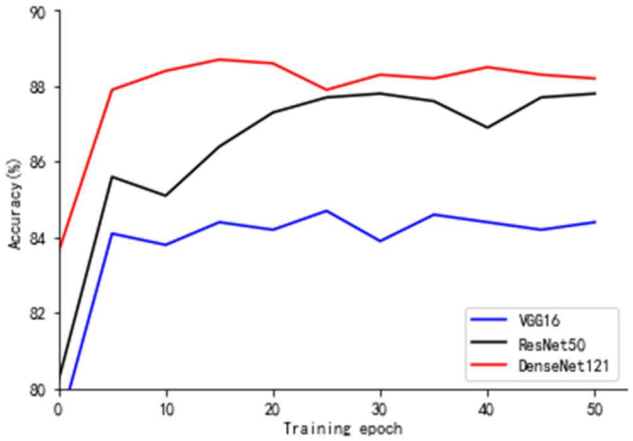

Figure 4. Accuracy changes of three different models on the testing set

Figure 5 shows the accuracy of all models in the experiment on the same test data set. It can be seen that the date classification accuracy with the Stacking integrated model is in excess of 91.88%, which is higher than that with a single algorithm. This is because the single classifier in training for a variety of reasons into local optimum, appeared the phenomenon of fitting, cause model generalization ability is not strong, and Stacking integration model integrating single classifier performance, reduce or avoid the risk of the foregoing, so as to enhance the generalization ability, raise the red jujube classification accuracy.

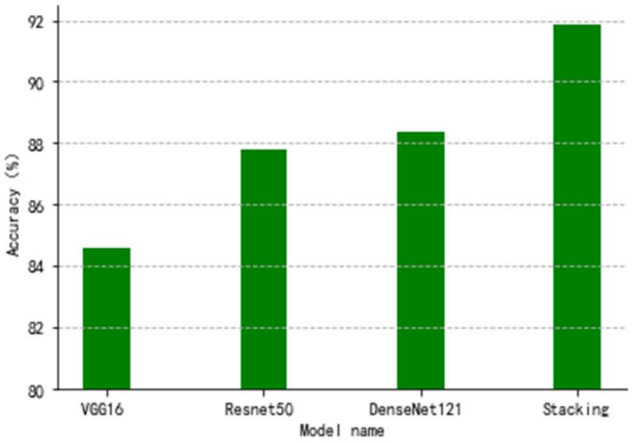

Figure 5. Classification accuracy of different models for the same dataset

4. Conclusions and Discussion

In this experiment, a Stacking model fusion method based on convolutional neural network is proposed for the classification of grey dates. The data set was constructed by manual annotation through image clipping, gaussian noise, scale scaling, normalized size and other data enhancement operations. A Stacking integrated learning model with VGG16, ResNet50 and DenseNet121 convolutional neural networks as the base learner and logistic regression as the secondary learner is constructed. Using the same data set, the same hyperparameters and the same operating environment, the comparison between the integrated model and the single neural network model is carried out. Through the experiment research shows that the Stacking integration model in red jujube classification tasks can reach 91.88% accuracy, on the basis of the single best model accuracy improved 4.6%, this method can effectively increase the red jujube grading accuracy rate, meet the

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daily demand for red jujube grading, provides reference for the machine to replace the ordinary manual sorting.

Generally speaking, the greater the difference of the base learner model, the more the number can increase the accuracy of the integration model. In the future, it is necessary to further optimize the base learner of Stacking model and consider increasing the number of base learner. The parallel acceleration mode is adopted to improve the efficiency while ensuring the accuracy, reduce the calculation time and operation and storage overhead, and reduce the configuration requirements of computer hardware system. Meanwhile, the data preprocessing is strengthened to expand the data set capacity, so as to achieve the classification of red dates in more complex scenarios.

Acknowledgments

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