Lung CT image aided detection COVID-19 based on Alexnet network

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***Abstract*—In this article, we use the Alexnet network in deep learning to determine whether the lung CT images are infected with covid-19.First of all, in the data preprocessing stage, the original CT image data is scaled and normalized to reduce noise interference. The batch operation of training set and test set can increase the training speed;Secondly, build an eight-layer Alexnet network model, set reasonable hyperparameters for each layer of the network, define the loss function and optimizer, and use the processed data to train the weight parameters of each layer in the network model.Finally, three indicators of accuracy, accuracy and recall are used to quantify the effect of model classification, and the impact of different training times on these three indicators is compared to select the best classification model.At the same time, use pyqt5 to write the corresponding auxiliary detection interface to facilitate the display of test results and the selection of classification models.The construction of the network model, the definition of the loss function and the definition of the optimizer are all based on the Pytorch deep learning framework.**

Keywords—Deep learning, Alexnet neural network,Medical image

I. Introduction

Since December 2019, pneumonia caused by a novel coronavirus infection has occurred in Wuhan, Hubei Province, China. The World Health Organization (WHO) announced that the disease caused by this virus was officially named "new coronavirus pneumonia (COVID-19)" [1]. The latest research results show that CT has strong sensitivity in the diagnosis of COVID-19 patients, and the positive rate of CT in confirmed patients is greater than 90%, which is of great significance for the diagnosis, treatment, prevention and control of COVID-19 patients [2-4]. At the same time, in the face of large-scale disease outbreaks, the shortage of medical staff has also become a common problem facing the world. With the rapid development and rise of computer technology, the emergence of artificial intelligence technology combined with big data-deep learning has provided a huge help for solving medical problems. In view of the many advantages of deep learning, more and more scholars are beginning to apply it to medical image-assisted detection, which effectively makes up for the shortcomings of traditional medical technology [5].

In this article, we use the AlexNet convolutional neural network in deep learning to learn the lung CT of normal people and the lung CT of patients infected with COVID-19, and obtain the classification model to provide auxiliary detection for the doctor's diagnosis.

The AlexNet network [6-8] is a convolutional neural network proposed by KrizhevskyA and others in 2012 and won the championship in the ILSVRC competition that year. Its network structure is shown in Figure 1, which is divided into 8 layers, including 5 convolutional layers and 3 fully connected layers. The first, second, and fifth convolutional layers are followed by a pooling layer (maximum pooling), and the third and fourth convolutional layers have no pooling layer; each convolutional layer contains the activation function RELU and local area Normalized LRN, the last three fully connected layers transform the two-dimensional feature maps into one-dimensional column vectors. In order to prevent overfitting, the sixth and seventh fully connected layers still use the ReLU function as the activation function, but the eighth layer is fully connected. As the classification layer, the connection layer has no activation function [9].

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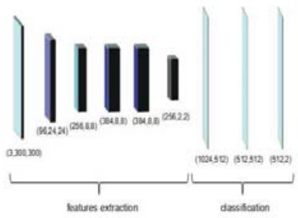

Fig. 1. Alexnet network structure diagram

II. DATA PREPROCESSING

The data set for network model training and testing comes from Hewhale Community (kesci). The images of the data set are divided into two categories, including lung CT images of people with COVID-19 and lung CT images of normal people. The labels are 1 and 0. Then all data is randomly divided into training set and test set, where the test set accounts for 30% of the total data. At the same time, batch_size needs to be set separately for the training set and the test set. Use the DataLoader provided in torch to generate batch_size data units. What is generated by DataLoader is an iterator, which can get data through a for loop, which greatly facilitates the training and testing of the network model later.

III. CONSTRUCTION OF NETWORK MODEL AND ITS TRAINING PROCESS

In this article, we use the AlexNet network, which can perform feature selection and image category classification for input images. The AlexNet network has five convolutional layers for image feature selection, and three fully connected layers for image classification.

A. Image feature selection

In the traditional machine learning related algorithms in the past, the image features need to be obtained in advance using PCA and other dimensionality reduction algorithms, and the selection of features is sometimes good and bad. For deep learning, it is an end-to-end mode. The original image input is used to directly obtain the classification results. The selection of features is implemented by the convolution structure inside the neural network. For the AlexNet network used in the classification of lung CT, its feature extraction network is shown in Figure 2. In this network, the original input image is a 3-channel 300x300 lung CT image, and its characteristics are obtained through five convolutional layers.

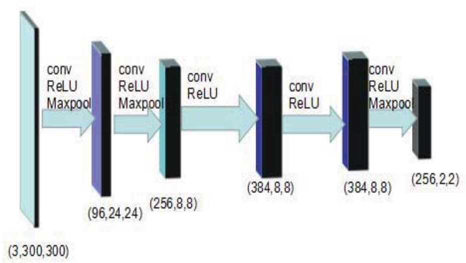

Fig. 2. Network structure of feature extraction

It can be seen from Figure 2 that there are three main operations in the image feature extraction network, namely two-dimensional convolution, ReLU activation and maximum pooling. For convolution and pooling, the size of the image will be changed, while ReLU activation only increases the non-linear mapping, and does not change the size of the image. In the process of building the network, after multiple convolutions, activations, and pooling, a 256-channel 2x2 result was finally obtained.

B. Image classification

For image classification, a fully connected form similar to the LeNet network is used to convert the features extracted from the feature into a one-dimensional form, and then use three linear layers to classify according to the feature, and then use the sigmoid function to output two classification results, the specific classification The network is shown in Figure 3.

As can be seen from Figure 3, the order of use of the three linear layers, the first and second linear layers use the ReLU activation function for nonlinear mapping. If there is no nonlinear mapping of the ReLu function, the three-layer network can be linearly combined , Which is similar to using only one layer of network, which reduces the classification effect. At the same time, the Dropout layer is used after the first and second linear layers to discard some neurons to avoid overfitting in the linear layer. Finally, use the softmax function to output.

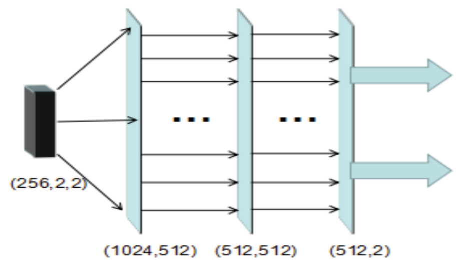

Fig. 3. Classification network structure diagram

C. Training process

For the constructed AlexNet network to get good training results, it is also necessary to find a suitable loss function and an optimization method for back propagation.

As a classification problem, CrossEntropyLoss() provided by the pytorch deep learning framework is used as the loss function of the neural network. The specific loss function expression is:

$$\operatorname{loss}(x, class) = -\log\left(\frac{\exp(x[class])}{\sum_j \exp(x[j])}\right) \quad (1)$$

$$\operatorname{loss}(x, class) = -x[class] + \log\left(\sum_j \exp(x[j])\right) \quad (2)$$

Where j represents the number of neurons in the output layer, that is, the total number of categories, and x[j] represents the output value of a certain neuron.

After defining the loss function, you need to define the optimizer used. Similarly, Pytorch provides a large number of optimizers for us to train the network. In this example, the most commonly used gradient descent algorithm in the field of machine learning is selected to compare each of the network The weight of the layer is updated.

After the loss function and optimizer are defined, the training of the model can be started. Take a batchsize of data each time (this work has been completed during data preprocessing), and transfer the data to the model to obtain the output value of the model, and then use the loss function to obtain the loss of the output value and the true value, and the loss will be obtained Backpropagation is performed once to obtain the partial derivative of the weight of each layer, and finally the weight of each layer is updated by the optimizer. After the update, the partial derivative of the weight of each layer needs to be set to zero.

After the training process is written, the network model is trained for 30, 70, and 100 times to obtain three network models, and three sets of loss values obtained from the loss function. The comparison of the three sets of loss values is shown in Figure 4.

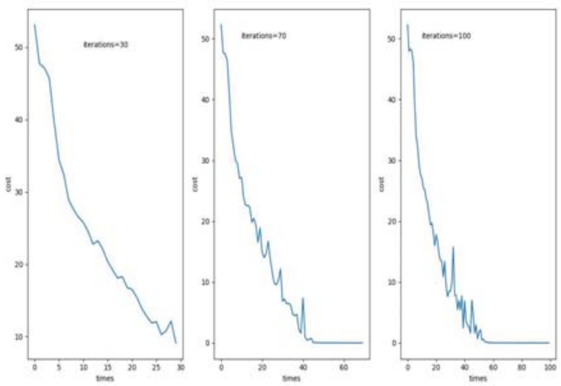

Fig. 4. Loss function curves with different iterations

It can be seen from the loss function curves of different iteration times that for the current network model and data set, after the number of training iterations reaches a certain value, the loss value of the model has basically no longer changed.

IV. Model performance evaluation

For our trained model, sometimes it cannot meet our real needs. Therefore, before applying the trained model, we need to obtain a quantitative evaluation of its performance on the test set. In this article, the trained model is scored in terms of accuracy, precision and recall.

A. Analysis of model accuracy

Accuracy refers to the number of correct data points in the test data set divided by the size of the entire test data set. In this article, when CT images are classified into normal and COVID-19, the accuracy rate represents the proportion of correct classification.

The model was trained 30, 70, and 100 times, and the three models obtained were used to run on the test set, and three accuracy rates were obtained as shown in Table 3-1.

TABLE I. THE RELATIONSHIP BETWEEN TRAINING TIMES AND ACCURACY

Training times	Accuracy
30	90.20%
70	91.32%
100	90.90%

The accuracy change curve for different training times is shown in Figure 5. It can be seen from Figure 5 that the accuracy rate change curve is divided into two parts: the rising phase and the stable phase. In the ascending phase, the accuracy rate increases as the number of training increases. After reaching the stable stage, the accuracy of the model will not become better as the number of training increases.

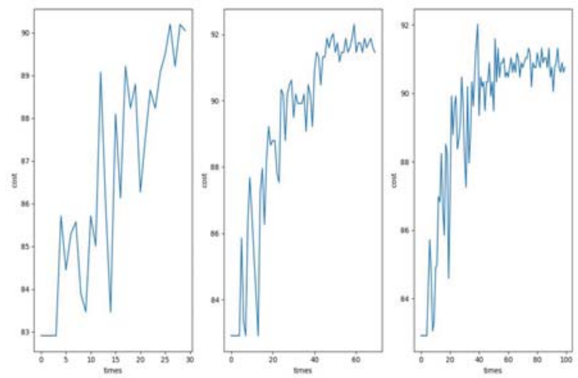

Fig. 5. Accuracy curves of different iterations

B. Analysis of model precision

Precision describes the ability to not classify images of COVID-19 as normal. That is, in the test set, among the images classified by the model as suffering from COVID-19, it is the proportion of images that are really suffering from COVID-19. Similarly, the precision rates of the three models are shown in Table 3-2.

TABLE II. THE RELATIONSHIP BETWEEN TRAINING TIMES AND PRECISION

Training times	Precision
30	68.31%
70	73.44%
100	74.36%

C. Model recall analysis

The recall rate (or sensitivity rate) describes the ability to find COVID-19 from all the images of COVID-19. In other words, among all the images suffering from COVID-19 in the test data set, the recall rate is the proportion of images that are correctly identified as COVID-19. The recall rates obtained by using the three models are shown in Table 3-3.

TABLE III. THE RELATIONSHIP BETWEEN TRAINING TIMES AND RECALL RATE

Training times	Recall
30	79.51%
70	77.05%
100	71.31%

Comparing the three performance indicators of three different training times, you will find that when the number of training times reaches 70 times, it has better performance than 30 times and 100 times. As the number of training increases, the model will overfit, which will result in worse results when the model is applied to the test set.

V. VISUAL INTERFACE

Because it is used as an auxiliary detection, the final rendering effect cannot be in the form of command lines. Here, use PyQt5 to write the corresponding auxiliary detection interface, which is more convenient and more general to display auxiliary detection results. The interface is shown in Figure 6.

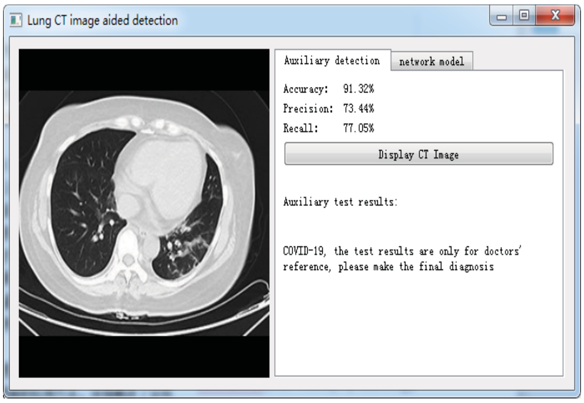

Fig. 6. Operation interface of lung CT image aided detection

It can be seen from Figure 6 that the operation interface is mainly composed of two parts: the left part is the lung CT image display area, and the right part is the display area of some parameters and auxiliary detection results. The performance score of the used model is displayed on the right side, which is convenient for knowing the credibility of the auxiliary detection results of the model. The button is used to switch the displayed CT images, and the model detection results corresponding to the left lung CT image are displayed at the bottom.

Among them, in the network model page, you can select different network model classes for auxiliary detection. The specific operation page is shown in Figure 7.

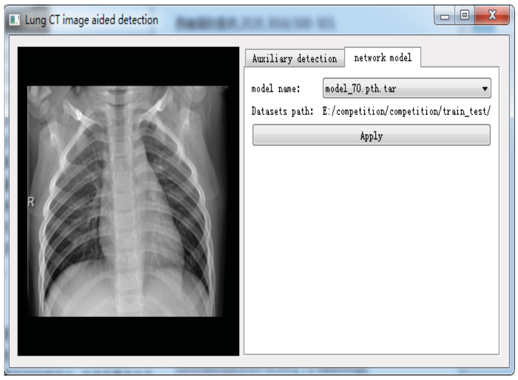

Fig. 7. Network model selection page

VI. CONCLUSION

In this paper, a lung CT image aided detection method based on Alexnet network is proposed. The implementation process and the final performance score are described in detail. Overall, this paper is divided into four modules: data preprocessing module, network structure building and training module, model performance test module, interface application presentation module. At the same time, it is found that the classification accuracy of this method for lung CT images can reach 90%, and the over fitting phenomenon will appear for more training times, which will lead to the decrease of the accuracy.

ACKNOWLEDGMENT

This work was supported by the Key Research and Development Program of Shandong Province (2017CXGC0916);Shandong Academy of Sciences Collaborative Innovation Fund (2018CXY-3);Youth Science Funds of Shandong Academy of Sciences (2019QN0015); Shandong key research and development plan (2019JZZY020319);Shandong key research and development plan(Public welfare science and technology research) (2019GGX104005).

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