Design of Intelligent Classroom Attendance System Based on Face Recognition

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***Abstract*—It is time-consuming and laborious for classroom attendance methods in Chinese universities, and the attendance costs are too high. In this paper, we use the deep learning related ideas to improve the AlexNet convolutional neural network, and use the WebFace data set to improve the network training and test. The Top-5 error rate is only 6.73%. We applied this model to face recognition and combined with RFID card reading technology, which developed a smart classroom attendance system based on face recognition. Research shows that the system is efficient and stable, which effectively reduce classroom attendance costs.**

***Keywords*—face recognition; class attendance system; AlexNet convolutional neural network; RFID technology**

I. INTRODUCTION

Higher education institutions pay more attention to the cultivation of students' independent ability. However, students generally have the phenomenon of skipping classes or even substituting classes, which lead to poor training in higher education, seriously affecting the improvement of students' professional level. For such phenomena, the general method is to make a roll call or sign the time table. These two methods are waste time and energy. They will take up a lot of class time and cannot solve the problem of signing when the number of students in the class is large.

The classroom attendance system is based on face recognition technology, combined with RFID technology [1]. It realized the identity confirmation of the students in the class effectively. Through the real-time test of the algorithm, it fully meets the requirements of the attendance time in the class, reduces the attendance cost of the classroom, and effectively solves the problem of signing and other issues.

II. SYSTEM PROCESSING FLOW

The classroom attendance system based on face recognition technology uses the camera to monitor the scene information. It triggers the shooting of the student face photo event, reads the student information when the student is signed in with campus card, which prevents non-school personnel from entering the classroom and substitute classes. What's more, the improved AlexNet convolutional neural network algorithm is used for feature extraction, and the extracted features are stored in the back-end database. After the student "show him face", the convolutional neural network is used again for feature extraction and compared with the student characteristics after the campus card is swiped. The system processing flow chart is shown in Figure 1.

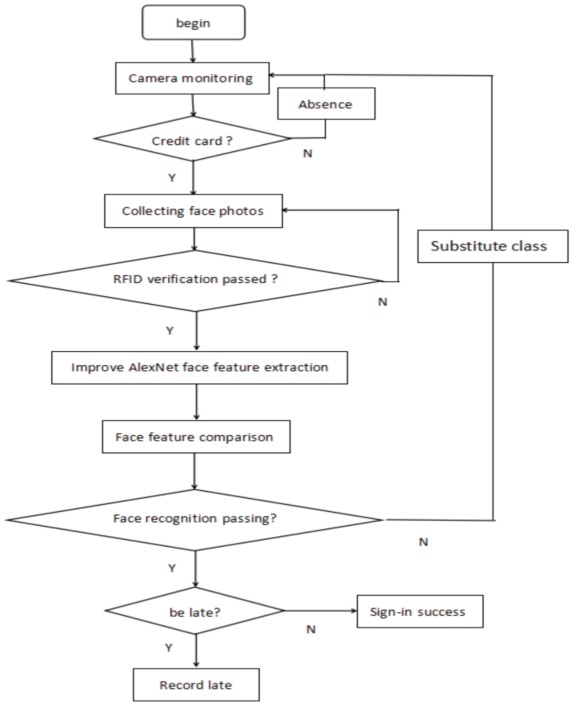

Fig.1. System processing flow chart

III. CORE ALGORITHMS AND TECHNOLOGIES

A. *Face Feature Extraction and Comparison*

Face feature extraction and comparison consists of three parts, face position detection, face feature extraction, and face feature comparison [3]. The improved AlexNet convolutional neural network performs the above three parts of the work.

(1) Improvement of AlexNet Convolutional Neural Network.

The AlexNet Convolutional Neural Network was designed by 2012 ImageNet competition winner Hinton and his student Alex Krizhevsky. The network designed by the network has a recognition rate of more than 80% on the ImageNet dataset, which compared with the 70% correct rate of the traditional machine learning method at that time, the recognition accuracy has a qualitative leap [4]. It use a highly parallel GPU acceleration technology and deepening the number of network layers, and using the ReLU activation function and adding Dropout effectively prevent network overfitting[5], the network structure is shown in Figure 2.

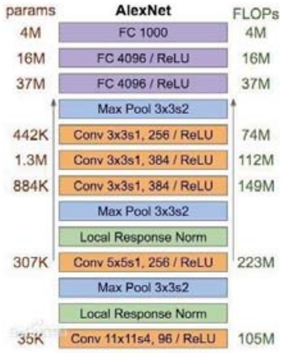

Fig.2. AlexNet network structure

When AlexNet operates on the convolutional layer, the formula is [6]:

$$y_n^p = f(\sum_{i \in T_n} y_m^{p-1} * k_{mn}^p + b_n^p) \tag{1}$$

Where y_n^p is the nth channel output of the convolutional layer p; $f()$ is the activation function, the activation function used in AlexNet is the ReLU function; T_n is used to calculate the total input feature map subset; k_{mn}^p represents the convolution kernel; "*" indicates a convolution operation.

When performing a pooling operation, the formula is calculated as [6]:

$$y_n^p = f(\omega_n^p pool\left(y_n^{p-1}\right) + b_n^p) \tag{2}$$

Where, ω_n^p represents the pooling layer weight parameter, and $pool()$ represents the pooling function. By sliding the window method, the maximum pooling operation is performed on the pixel, that is, the maximum value in each pixel block is obtained.

The AlexNet neural network is well designed and the Top-5 error rate is only 15.3% in the ILSVRC 2012 image recognition competition. However, there are some problems in this network: the top-level fully connected layer occupies too many parameters, and when the ReLU function is updated after the large gradient flow parameter is updated, it is prone to lock-up phenomenon [6], and it is easy to lose all negative input parameter information, and the LRN layer generalization ability gain is not strong, network structure is bloated. In response to these shortcomings, and combined with the application requirements of face recognition systems, propose the following improvements:

a) Remove the top layer FC 1000 full connection layer and change the last layer of FC 4096 layer to FC 2048 layer;

b) Change all ReLU activation functions to PReLU functions;

The ReLU function formula and the PReLU formula are as follows.

ReLU function:

$$ReLU(x) = \begin{cases} x & if\ x > 0 \\ 0 & if\ x < 0 \end{cases} \tag{3}$$

PReLU function:

$$PReLU(x) = \begin{cases} x & if\ x > 0 \\ a_i x_i & if\ x < 0 \end{cases} \tag{4}$$

In the formula, i denotes different channels. It is easy to know from (3)(4) that PReLU does not lose all negative input parameter information when the input is less than 0, so the training lock phenomenon is not easy to occur [8].

c) Remove all LRN layers;

d)Change the first layer convolution layer to 9*9 convolution kernel, the second layer convolution layer 5*5 convolution kernel to two 3*3 convolution kernels, and remove the 4th layer 3* 3 convolutional layers.

Let the size of the convolution input feature map be $H_{input} \times W_{input} \times C_{input}$ to indicate the length and width of the image and the number of input channels, $H_{output} \times W_{output} \times C_{output}$ is the output feature map size, and the convolutional layer improvement follows the formula:

$$\begin{cases} H_{output} = \left(H_{input} - F + 2P\right) / S + 1 \\ W_{output} = (W_{input} - F + 2P) / S + 1 \\ C_{output} = K \end{cases} \tag{5}$$

In the formula, F is the length of the convolution kernel, P is the number of all 0 filled layers, S is the step size, and K is the number of output channels.

The pooling layer improvement follows the formula:

$$\begin{cases} H_{output} = \left(H_{input} - F'\right) / S + 1 \\ W_{output} = (W_{input} - F') / S + 1 \\ C_{output} = K \end{cases} \tag{6}$$

In the formula, F' is the pooled core side length, and the rest is the same as the convolution layer improvement formula.

The improved network structure is shown in Figure 3.

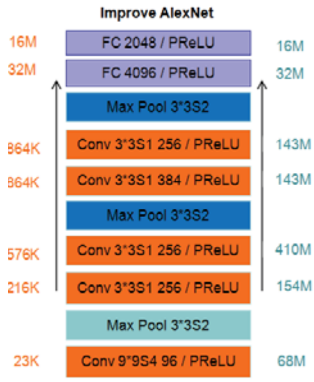

Fig.3. Improved AlexNet network structure

(2) Training Improved AlexNet Network

The data set used in the training improvement network is the CASIA-WebFace face data set, which contains 10,000 people and a total of 500,000 face photoes. An example photo is shown in Figure 4.

Fig.4. CASIA-WebFace sample picture

In this paper, 500,000 photos in the data set are divided into training set and test set according to the ratio of 7 to 3. The pixel image pixels are compressed to 225*225*3, and the network is trained and tested.

The number of improved AlexNet network training rounds is 35 steps. The change of Top-5 error rate of each parameter in the improved network is shown in Figure 5.

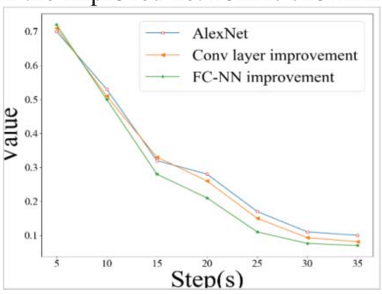

Fig.5. Improvement process Top-5 error rate change

After the change of the Top-5 error rate line graph, the convolutional layer parameters change and the number of related layers are reduced, the error rate is reduced more. On this basis, the full connection layer is changed, and the activation function is changed to PReLU. The Top-5 error rate dropped significantly to 6.73%.

(3) Algorithm real-time analysis and application.

Considering the real-time requirements of the classroom attendance system, efficient extraction is required when the algorithm is required to extract features. Analyze the running time of the algorithm, select any face photo, preprocess the image in windows7, 64-bit system, 8G memory, GPU acceleration environment, and perform AlexNet network and improved AlexNet network feature extraction. The comparison of the total time of preprocessing and feature extraction is shown in Figure 6.

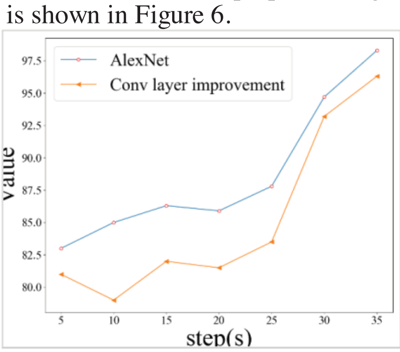

Fig.6. Comparison of total time of preprocessing and feature extraction

According to the total time of feature extraction, the feature extraction time of AlexNet after 35 steps of training is 109ms. The improved AlexNet has reduced the network parameters and removed the LRN layer, and the feature extraction time is reduced to 98ms. Time performance meets the real-time needs of the application.

When the attendance system is applied, students will collect facial images at the beginning of each semester, and use them for attendance in this semester. The extracted face image is preprocessed and sent to the trained convolutional neural network for feature extraction. After extraction, the corresponding identity feature is stored in the backend database.

B. RFID Technology

RFID is a non-contact RF card reader technology that relies on the unique logo of an electronic tag. The complete RFID card reader system consists of a reader, an electronic tag, a transponder and an application system. The working principle is that the reader transmits a certain frequency of radio waves to the transponder, and the reader receives the interpretation data in order and sends it to the application for processing .

The system uses RFID technology and uses student campus cards as electronic tags. After entering the classroom, the students first credit the campus card and uniquely identify it according to the card number of the campus card. Once the campus card is close to the reader, the radio waves emitted by the reader are received by the electronic tag, and the reader receives the decoded card number data in sequence. Upload the decoded data to the server that manages the student information, compare it with the stored student information, and determine the identity of the campus card.

After determining the identity, the saved face features of the corresponding student identity are obtained, and the face photos taken by the camera are preprocessed and feature extraction is performed using the improved AlexNet network. The two features are compared by cosine similarity. When the similarity exceeds the empirical threshold of 0.75, it can be considered as the same person. In order to adjust the empirical threshold parameters and determine the optimal threshold, 1000 college students from the Information Technology Institute were selected to collect face photos at the beginning of the school and the beginning of the class. After the image is preprocessed, the trained model is tested, and the cosine similarity threshold parameter is adjusted. The relationship between the test correctness rate and the threshold parameter is shown in Figure 7.

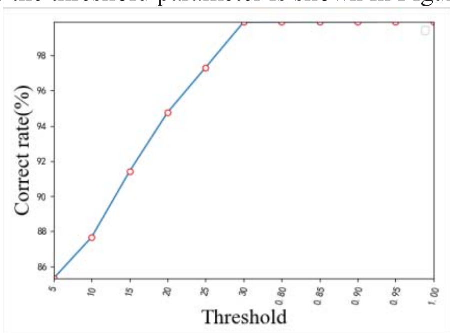

Fig.7. Relationship between test accuracy and threshold parameters

From the relationship between the test accuracy and threshold parameters, when the cosine similarity threshold parameter is greater than 0.75, the test accuracy rate tends to be stable, roughly at 99.90%, so the threshold parameter of the system is set to 0.75.

IV. ATTENDANCE MANAGEMENT SYSTEM

The background attendance management system adopts the B/S architecture, and the administrator can log in to the relevant page by using the browser to implement attendance management. The front-end data is passed to the back-end management system in real time, and the administrator can perform real-time processing. The main functions include: course data query analysis and various management functions. Management functions include: attendance management, course and classroom management, and personnel management.

A. *Management function*

(1) Attendance management

Attendance management functions include deletion and modification of student attendance information data. You can delete or change the status of check-in, absenteeism, late arrival, and substitute students.

(2) Course Management

Course management includes course management, tuition, and course selection. The course management function adds, modifies, and deletes courses. The tuition function can be modified for each classroom and teacher. The course selection function can query the student's course selection information and import it in batches.

(3) Personnel management

Personnel management includes teacher management and student management functions. Teacher management can implement query to teachers, add, modify, delete teacher information, student management to achieve student query, add, modify, delete student information, and import student information in batches.

(4) Classroom management

Classroom management includes the addition, modification, and deletion of all information in the classroom.

B. *Analysis of class rate*

The course data query analysis mainly includes the class rate inquiry, the same class analysis, and the same class analysis.

The rate-based query function allows administrators and teachers to view the status of each class for each class. The corresponding date and corresponding course can be selected. There are four states: normal check-in, absenteeism, late arrival, and substitute classes. They are denoted by the symbols "√", "×", "-", "*", respectively. The class rate query display is shown in Figure 8. The figure shows the attendance rate of the "Student Employment and Entrepreneurship" course for the second semester of the 2017-2018 academic year in a Chinese university.

序号	学号	姓名	班级	03/08 15:30	03/15 15:30	03/22 15:30	03/29 15:30	04/05 15:30	04/12 15:30
1	201522450601	陈云	计算机类15_4	√	√	√	√	√	√
2	201522450602	杨亚楠	计算机类15_4	√	√	√	√	√	√
3	201522450603	穆震	计算机类15_4	√	√	√	√	√	√
4	201522450604	王宁	计算机类15_4	√	√	√	√	√	√
5	201522450605	王梓芃	计算机类15_4	√	√	√	√	√	√
6	201522450606	周佳美	计算机类15_4	√	√	√	×	√	√
7	201522450607	闫茉荣	计算机类15_4	×	*	√	√	√	√
8	201522450608	赵若帆	计算机类15_4	√	√	√	√	√	√
9	201522450609	杜晨	计算机类15_4	√	√	√	√	√	√
10	201522450610	王红冉	计算机类15_4	√	√	√	√	√	√
11	201522450611	刘文浩	计算机类15_4	√	√	√	√	√	√
12	201522450612	李凤	计算机类15_4	√	×	√	√	√	√
13	201522450613	阚瑛睿	计算机类15_4	√	√	√	√	√	√
14	201522450614	周坚雄	计算机类15_4	*	√	√	√	√	√
15	201522450615	康玉格	计算机类15_4	√	√	√	√	√	√
16	201522450616	刘之帅	计算机类15_4	√	√	√	√	√	√
17	201522450617	刘国鹏	计算机类15_4	√	√	√	√	√	√
18	201522450618	徐霖逸	计算机类15_4	√	√	√	√	√	√
19	201522450619	苗一	计算机类15_4	-	√	√	√	√	√

Fig.8. Class rate analysis function display

The same class analysis function can count the different classes of the same class to the class rate and visualize. According to this data, it is possible to analyze the learning status and the degree of love of different courses of the same class, which is helpful for the adjustment and reform of college courses.

The same class analysis function can count and classify the students' attendance rates of different teachers in the same course. It can be used as a reference for students' preference for teachers' teaching methods, so as to encourage teachers to prepare lessons and lectures. The same class analysis function is shown in Figure 9. The figure shows the different teachers in the "Computer Network Course", which contains teacher Zhao, teacher Zeng, teacher Zhai, teacher Sun and teacher Cao.

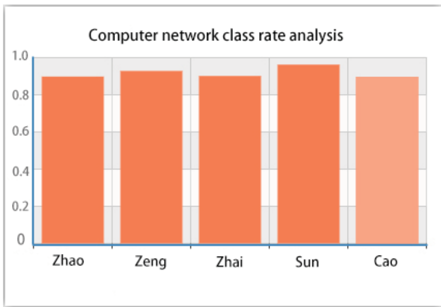

Fig.9. Shows the same class analysis function

V. CONCLUSION

This paper first introduces the overall design idea of the intelligent classroom attendance system, and then improves the AlexNet convolutional neural network. What's more, we verifie the necessity and effectiveness of the improvement from multiple angles, then introduces the application of RFID in the system. Finally, the function and description of the back-end attendance management system are carried out. The experiment proves that the smart classroom attendance system based on face recognition technology is efficient and stable, which effectively reduces the classroom attendance cost.

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