Design of Classroom Check-in Algorithm Based on Face Recognition

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Abstract: In order to understand the attendance of students in the classroom quickly and accurately, this paper proposes a classroom face recognition check-in algorithm developed based on Python language and OpenCV library. The Video Capture function provided by OpenCV library is used to call the camera for image acquisition, and then the acquired image is preprocessed to realize face detection using Haar-like features, the LBPH algorithm is used to extract features from the face image, and a training model is obtained through feature training and stored in the database. After the check-in is initiated, the acquired images are preprocessed, face detection and feature extraction are performed, and they are compared with the model previously stored in the database. The experimental results show that the algorithm is able to efficiently and accurately realize classroom face recognition check-in while ensuring lower cost.

Keywords: Open CV; Face Recognition; Face Detection; LBPH; Live Face Recognition

1. Introduction

With the rapid development of the information age, artificial intelligence technology has advanced by leaps and leaps, and face recognition has also become one of the popular technologies in the current intelligent era, and is widely used in all walks of life. With the continuous deepening research of face recognition technology, the accuracy and security of face recognition have been greatly improved, so that it has been widely used in banking business, public security identity identification, face unlocking and other aspects [1]. Nowadays, face recognition can be seen everywhere in our field of life.

Some of the students who enter college life want to relax themselves and begin to slack off on their studies because the tight life in high school is over. So many college students have the phenomenon of being late, leaving early and skipping classes, which seriously affects the classroom discipline and learning atmosphere. The use of a fast and accurate check-in system can effectively track the attendance of students, and then help to urge students to develop the habit of coming to the classroom on time, so as to improve the existing bad learning atmosphere to a certain extent [2].

2. Classroom Check-in Algorithm Design Background

At present, some students in many colleges and universities in China are tired of class and do not want to study. They frequently arrive late, leave early and skip classes, and there are even students who have not been to the classroom. College is a period of preparation for entering the society. If students are allowed to waste this precious study time, it may make them unable to graduate successfully and affect their work and life after graduation. In order to ensure the quality of teaching and give students a suitable normal grade, the classroom attendance has become an important part of the teaching process. At present, most of the attendance methods are name checking in, which is a waste of time and energy, and there are others to help sign in [3]. Although the mobile phone scanning code check-in is fast, but there is also a mobile phone and people are not in the signing situation. Therefore, the use of face recognition technology for classroom check-in, can not only quickly and convenient access to students' attendance information, but also can effectively prevent others instead of sign-in phenomenon

[4].

3. Face Recognition Technology

In ancient China signature signature to identify identity method, and use of biometric to identify identity has been a research hotspot at home and abroad, common biometric technology has fingerprint recognition technology, face recognition technology and iris recognition technology, the recognition technology is widely used in our life, such as fingerprint unlock, brush face entrance guard, iris door locks, etc [5]. Each biometric technology has its own unique advantages. The three recognition technologies are compared according to whether automatic detection, identification method and accuracy. The results are shown in Table 1.

Table 1. Comparison of the Three Biometric Techniques

	Fingerprint	Face	Irises
Auto	No	Yes	Yes
Method	Direct contact	No contact	Close range
Accuracy	Easy imitation	High	High

As can be seen from Table 1, among these several biometric technologies, face recognition has the advantages of simple, fast, no contact and high accuracy [6].

Face recognition technology is to collect people's face video stream through the video equipment, and collect a frame from the video stream for detection and positioning, and then preprocess the face picture, and then feature extraction, and finally put the final data stored into the database. After that, every time a face is scanned, the face can be extracted and compared with the data stored in the database before. If the two match, the recognition will be successful.

In the early stage of face recognition research, also known as the semi-automatic face recognition stage, it mainly uses the method based on the face geometric structure features, which uses the differences in the shape and structure of face organs between individuals to distinguish. The approach for this period requires manual selection of different organs on the face as features. With the rapid development of face recognition, it enters the stage of human-computer interaction identification, mainly based on subspace method and statistical methods. To today's intelligent face recognition stage, there are a variety of face recognition methods, they have their own characteristics, so now it is mainly to study and improve the defects of these face recognition methods.

4. Check-in Algorithm Implementation Process

In recent years, deep learning has made important breakthroughs in the field of artificial intelligence, making it a great success in computer vision and image processing [7]. Face recognition based on deep learning is also widely used, and face recognition algorithms based on CNN and YoLov5 have the advantages of strong learning ability and fast computing speed, but they usually rely on a large amount of training data. If the training data is insufficient, the accuracy of the model will decrease [8][9]. A large amount of training data makes the amount of computing, hardware demand high, so the cost is high.

OpenCV is an open source cross-platform computer vision library, can run on a variety of operating systems and support a variety of computer language interfaces, but also provides a large number of operating interfaces and functions, can achieve a lot of image processing and computer vision general algorithms [10]. Local Binary Pattern Histogram face recognition algorithm provided by the library, also known as LBPH algorithm, has fast computing speed, strong anti-interference ability, and good robustness to illumination. Compared with other deep learning algorithms, it has a small computational amount and low cost. Therefore, this paper chooses the LBPH algorithm to realize face recognition.

The present algorithm is implemented using the Python language and the OpenCV library, and its overall flow is shown in Figure 1. First, the students' face information is collected through the camera equipment and associated with the students' information. Then, then the collected face pictures are preprocessed, detected and located, and then the face image features are extracted, and the obtained data information is stored in the database for feature training. After this, every time the check-in is initiated, the human face is scanned, and the acquired face will be detected and extracted, and then compared with the data stored in the database to see whether it matches, and the final output result.

4.1 Check-in Face Capture

In the sign-in face collection stage, it is necessary to collect face image, which can be collected with prepared photos or camera equipment. In this paper, the VideoCapture function provided by the OpenCV library is used to call the camera for image acquisition, and set the relevant parameters, and then preprocess the collected images. In collecting face information for students who need to face sign-in, in order to ensure the accuracy of detection, only one student should have a face in the face image, and the student's face should be clear. During the collection process, multiple face images of the same person were taken continuously through the camera, and the student's student number and name were correlated with the corresponding image. The collected face images were placed in a folder for feature training.

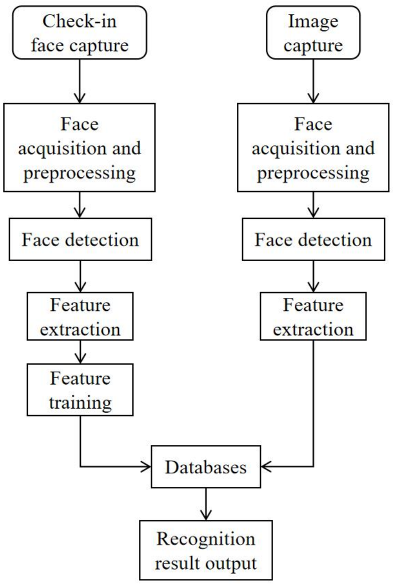

Figure 1. The Overall Process

4.2 Face Detection

In the OpenCV library there are cascading classifiers based on Haar-like features, it can judge whether there is a face in the video stream and picture. If there is a face, it can detect the position and size of the face, with the characteristics of fast speed and real-time detection. In this paper, it is used for face detection when check-in face collection and face sign-in recognition.

4.3 Feature Extraction

Face feature extraction is the process of transforming a face image into a string of fixed values through a certain method, which can represent the feature of the face. In this paper, the LBPH algorithm provided by OpenCV library is used for feature extraction in both check-in face collection and face recognition check-in.

4.4 Feature Training

After preprocessing, face detection and feature extraction of the images collected in the sign-in face acquisition stage, the feature training model is obtained and saved in the folder TrainModel for face recognition. The LBPH algorithm is characterized by fast computing speed and high efficiency. This paper uses it to train and learn the face feature data obtained by feature extraction.

4.5 Face Recognition

After check-in command initiated, and sign in face acquisition stage, through the VideoCapture function to call the camera image acquisition, after the image, then the preprocessing and face detection, judge face, if no face information, the image acquisition, when face information, the detected face image feature extraction with LBPH algorithm, and compared with the model data stored in the database, according to the similarity whether is the same students, to determine whether successful check-in. The face recognition flow chart is shown in Figure 2.

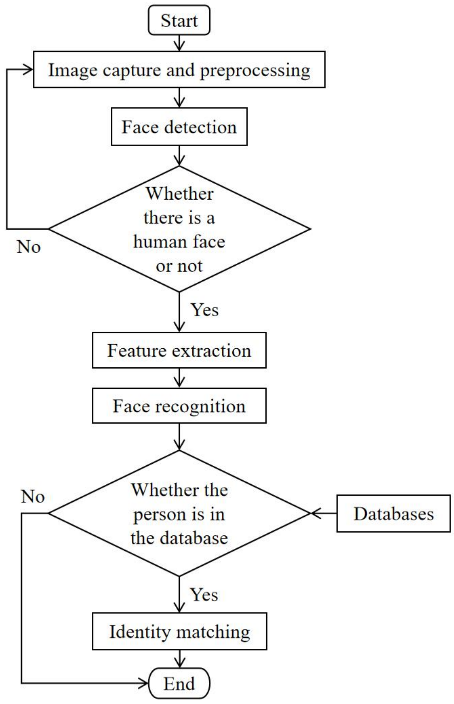

Figure 2. Face Recognition Flow Chart

5. Research on Human Face Recognition Algorithm

5.1 Image Gray-scale Processing

Because there are too many color image feature data, so in the image processing algorithm, the color image gray processing processing is usually required, and the image gray processing is the process of transforming a color image into a gray image. The pixels in the gray image have only one sample color, which is a multilevel color depth between black and white, with a minimum pixel value of 0 white and a maximum of 255 black. Color images usually include three components of R, G and B, respectively showing various colors such as red, green and blue. The gray makes the three components of R, G and B of color images into a value, which makes the image from three channels to single channel, thus making data processing much simpler. Using the OpenCV library call function for image acquisition requires gray-scale processing the color image using the cvtColor ( ) function.

5.2 Haar-like Feature Face Detection

Haar-like is a simple and efficient image feature. The Haar cascade classifier used in face detection is a classifier based on Haar-like features, which can detect the shape and size of the eyes, mouth, nose and other parts of the human face. Haar features include three categories: edge features, linear features, central features and diagonal features, which are combined into the feature template. There are two rectangles in the feature template, white and black. The feature value of a template is defined as the sum of the white rectangular pixels minus the sum of the black rectangular pixels. This feature value will be used to detect the face image to distinguish the face from the non-human face [11].

The main steps of Haar cascade classifier to achieve face detection: first, the Haar-like features of various parts of the face are extracted from the training sample, and each feature is composed of four rectangular areas, of which two rectangles are in the target area, and the other two rectangles are in the background area. A characteristic value is obtained by comparing the sum of the pixel values of the target region with the sum of the pixel values of the background region. After extracting the Haar-like features, these features were combined into a strong classifier using a cascade algorithm. The basic idea of the cascading algorithm is to combine multiple weak classifiers into a strong classifier [12]. During training, the error rate of the whole cascade classifier is minimized by constantly adjusting the parameters of the weak classifier. Finally, the trained weak classifiers are combined in a certain order to form a strong classifier. When conducting face detection, the acquired images were preprocessed to extract Haar-like features and then input into a strong classifier for classification. The Haar cascade classifier performed classification by comparing Haar-like feature values of faces and the non-face, with an output of 1 when the classifier judged the face and 0 when the classifier judged a non-face.

5.3 The Face Recognition Algorithm Based on LBPH

The face recognition algorithm used in this paper is the LBPH algorithm provided by the OpenCV library. This algorithm can efficiently and accurately realize the classroom face recognition check-in under the premise of ensuring a relatively low cost. LBPH algorithm divides the face image into many small local areas, then extracts the features of each small local area, and then series the features of each local region into an overall feature vector, and finally completes the similarity calculation. For each local region, the LBPH algorithm employs local binary patterns to perform feature extraction. Specific steps: First, the input image is divided into a number of small areas, generally pixel blocks, and each area is processed independently. The original LBP operator is defined within a window of 3 * 3, as shown in Figure 3.

5	4	5
17	6	8
3	2	6

Figure 3. The Original LBP Operator

For each region, a central pixel was selected and then compared to its surrounding pixels. Generally, the pixel value is compared between each pixel and its surrounding 8 pixels by default, and the comparison method is to compare the gray value of the central pixel with the gray value of the adjacent pixel. If the gray value of the adjacent pixel is greater than or equal to the gray value of the central pixel, the pixel is marked as 1 and the pixel is less than 0 [13]. The comparison results are shown in Figure 4.

0	0	0
1		1
0	0	1

Figure 4. Comparison Results

The comparison results are sorted clockwise starting from the top left corner to the first end of the second row, which eventually generates an 8-bit binary number that represents the result of comparing the center pixel with its surrounding pixels. This 8-bit binary number is then converted to a decimal number as the feature value of the current pixel, and this decimal number will be used as the LBP value of the region [14]. As in Fig. 4 the binary number obtained is 00011001, which is converted to a decimal number of 25.

Statistical the number of occurrences of each LBP value for the whole face image forms an LBP histogram that reflects the distribution of different texture features in the face image. Finally, the LBP histogram of each region is connected together to form the LBP feature vector of the whole face image. After obtaining this feature vector, we can calculate the similarity between the two feature vectors through the similarity measurement method, so as to complete the face recognition task.

Since the rotation of the image will get different LBP values, the rotation invariance processing should be done. Take the central pixel as the center, and then move the surrounding pixels in a clockwise direction. This gives the same LBP value regardless of rotating the texture in the image. LBP values were calculated for all images after rotation and then the minimum value was selected as the final value. This can further reduce the instability caused by the rotation.

5.4 Face Living Recognition

Live face recognition is an important part of face recognition, which prevents others from using photos, videos, and face models to complete face recognition in place of the person themselves [15]. In this paper, we use near-infrared face detection to prevent the use of others' photos and videos to help with check-in [16]. According to the optical flow method, the near-infrared face detection uses the time domain change and correlation of the image pixel intensity data to determine the "movement" of the respective pixel position, and then the Gaussian difference filter, LBP feature and support vector machine are used to analyze the running information of each pixel. At the same time, the optical flow field is sensitive to the movement of the object, and the optical flow field can uniformly detect eye movement and blink. The optical flow features in vivo are shown as irregular vector features, while photos and videos are regularly ordered vector features, so that the detection of living body can be completed.

6. Experimental Results

6.1 Algorithm Implementation Display

In this paper, when using the VideoCapture function for face image acquisition, display the input name and ID, here the ID represents the student number. After entering, press the return key, and the student is facing the camera. The computer will collect 50 photos continuously and save them in the Facedata folder. The effect of partial face image acquisition is shown in Figure 5.

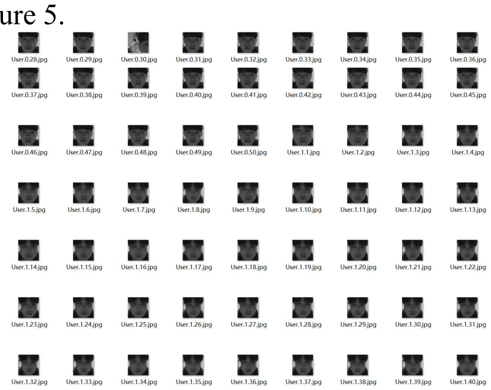

Figure 5. Face Image Acquisition Effect Diagram

The captured face images are subjected to face feature extraction and feature training to obtain a face model, which is saved in the TrainModel folder. After the check-in is initiated, the camera is also called through the VideoCapture function to capture images in real time, perform face tracking, perform preprocessing, face detection and feature extraction on the captured images, and then perform feature comparison with the previously trained face model to perform face recognition. In this paper, the matching threshold is set to 95, and when the matching degree is greater than 95 during face recognition, the recognition is successful, i.e., the sign-in is successful, and the student's name will be displayed on the face image in real time. The face recognition effect is shown in Figure 6.

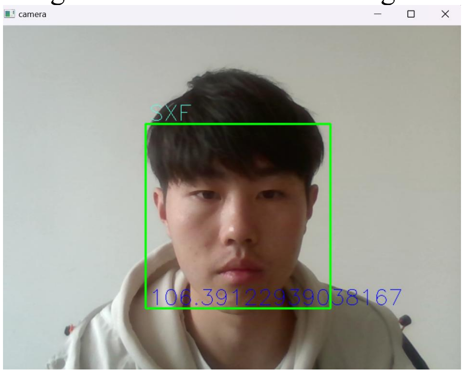

Figure 6. Face Recognition Renderings

6.2 Recognition Accuracy and Speed

In order to ensure the accuracy of recognition, this paper selects several face databases for testing under the premise of no living face recognition. The identified results are shown in Table 2.

Table 2. Identify the Results

Databases	Totals	Number of successes	accuracy
WebFace	50	48	96%
FaceScrub	50	47	94%
LFW	50	49	98%
CAS-PEAL	50	48	96%

The test results show that the recognition accuracy is more than 94%. Through the face recognition time test of different databases, the recognition time of a person is about 1.5 seconds, and the recognition accuracy and speed meet the requirements of fast and accurate classroom check-in.

7. Summary

Based on Python language and OpenCV library, this paper realizes the face recognition class check-in algorithm through LBPH algorithm. After various tests, the algorithm can realize the classroom check-in of face recognition at low cost and quickly and accurately, which meets the requirements of classroom check-in. LBPH algorithm to achieve high recognition accuracy must rely on a lot of training data, which means that in practical application need to spend quite a lot of time to collect and organize face information samples. Therefore, how to effectively improve the efficiency of data acquisition and processing while improving the recognition accuracy has become a key point for the algorithm to be further optimized.

Acknowledgments

This research was funded by the Natural Science Foundation of Sichuan (grant number 2023NSFSC1987).

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