

Design of Teaching Attendance System Based on Image Processing

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Abstract

Traditional classrooms often require teachers to roll call one by one in class, which not only affects the length of the class but also affects the quality of the class, and there is no timely data feedback, resulting in the lag of the work of many college students. This topic mainly uses computer simulation software for algorithm research, which is mainly divided into four parts, the first is the initial establishment of the face library, the second is the use of PCA algorithm for face image dimensionality reduction in face recognition, the Euclidean distance is used again for face closest matching, and finally the function is realized by GUI interface.

Keywords: image recognition, face recognition, MATLAB, PCA algorithm

1. Introduction

In recent years, there has been an increasing emphasis on disciplines in the size of the university student population problems of students, students absenteeism, difficulties in failing to pass, difficulties in graduation and other phenomena occur frequently.

At present, the commonly used forms of human identity verification mainly include magnetic cards, IC cards and identification numbers, and these technologies have now become mature, but this information is easy to be imitated and falsified, and there are many problems. However, face recognition is based on the inherent characteristics of the human face, which is difficult to imitate and has strong immutability, which is the mainstream scientific research direction. Face recognition technology has occupied a wide field in research that is still continuing in this work. [1]

The design is developed on the basis of the analysis of the technical characteristics of the PCA principal component analysis face recognition algorithm and the research status and difficulties at home and abroad, and the PCA algorithm based on principal component analysis is applied to reduce the dimensionality of the face image to obtain the face feature value, and the near-neighborhood K-L algorithm is used to match and recognize the face. In this dissertation, a face recognition system has been built using MATLAB. The camera is retrieved, the picture is collected, the face is positioned and segmented, and the face is compared with the sample database to obtain the comparison face. And the number of recognitions, time, etc. are displayed through the GUI interface. [2, 3]

The rest of this article is organized as follows. The second section introduces the algorithms related to image processing. In the third part, introduced facial feature localization, establishment of facial database, and optimization of algorithm usage. In the fourth section, simulation example is given to verify the effectiveness of the designed protocol. The fifth part summarizes the main content of this paper.

2. Algorithms Related to Image Processing

With the steady improvement of computer performance, the algorithm of image processing is also gradually following up, and the main algorithms of this system are PCA (Principal Component Analysis) algorithm based on face recognition and K-L (Karhunen-Loeve) transform.

2.1. Principal component analysis algorithm

The PCA algorithm is currently the most widely used data dimensionality reduction algorithm. The main idea of PCA is to transform r-dimensional features into k-dimensions, which are also known as principal components as a new orthogonal vector.

PCA work is to sequentially search for a set of mutually orthogonal coordinate axes in the original space. From Fig.1 can be observed that. The two axes mainly refer to two-dimensional data, and the black dots represent two-dimensional data points. If the data of one axis is projected onto the space of other axes, it can be reduced in dimension. The use of PCA method can greatly increase computational efficiency.

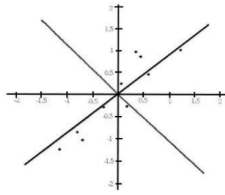


Fig. 1 Schematic diagram of two-dimensional data projection

2.2. Principle of k-l transformation

The K-L transform is essentially a method applicable to a wide range of random images. When the K-L transform is applied to N images, the images in the set composed of the transformed N new images are not correlated with each other. Obtaining a finite number of images M (M<N) restored from the transformed result image set will become the optimal approximation of the original image in statistical sense.

Assuming Y is an n-dimensional random variable, it can be represented by a weighted sum of n basis vectors.

$$X = \sum_{i=1}^n \alpha_i \varphi_i \quad (1)$$

Find the self coherence matrix of the random vector X.

$$R = E[X^T X] \quad (2)$$

Find the eigenvalues λ_j and eigenvectors φ_j of the autocorrelation matrix or covariance matrix R.

$$\alpha = \varphi^T X \quad (3)$$

2.3. Classifier recognition

Introduce the training sample data after dimensionality reduction of the transformation matrix into the classifier, complete classifier data training after specific classifier classification, match the reduced facial image data with the data trained by the original classifier, import the facial image to be detected into the system, and complete facial recognition based on the classification criteria of each classifier.

The Nearest Neighbor Classifier is currently one of the most theoretically sound algorithms in classifiers. It requires finding the closest m points, calculating the distance between this point and the other points, and then counting these m points to find the point with the highest weight and determine which category this point belongs to. The most important condition for the use of nearest neighbor classifier algorithms is to measure datasets of M-size that are close in distance. The formula used is Euclidean distance:

$$D(x, y) = \|x - y\| = \left| \sum_{i=1}^n (x_i - y_i)^2 \right|^{\frac{1}{2}} \quad (4)$$

3. Facial Feature Localization

In this design, it is necessary to locate the face. During the face detection process, the features of the eyes and mouth can be recognized and converted into specific vectors, which are then added to the PCA algorithm for subsequent processing.

3.1. Face detection

The main implementation process is to input any frame of image through the laptop camera, and the system automatically uses PCA face detection algorithm to distinguish whether there is a face in the input image. If a face is detected, it is then located, the relevant position information of the face is recorded, and the face is cropped to obtain an effective face image.

Facial detection scenarios can be divided into two types. One is to use computer cameras to directly capture facial images for detection and capture facial images; The second is to perform face detection on the images cached in the computer. If a face is detected, the contour information and position information of the face are recorded, and the relevant information of the person is displayed accordingly.

3.2. Facial image preprocessing

Due to the influence of different factors such as lighting, shooting angle, facial expressions, during the process of shooting in the same environment, image preprocessing is required, such as grayscale processing, binarization processing, histogram equalization, geometric normalization, in order to process the obtained facial photos.

For histogram equalization transformation, it can be divided into two types: normalized histogram and equalized histogram. Normalized histogram and equalized histogram are shown in Fig.2 and Fig.3.

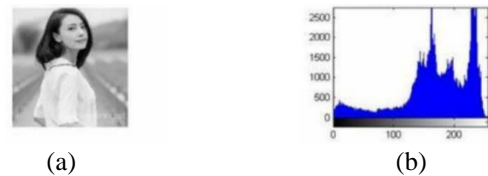


Fig. 2 Original image and corresponding histogram

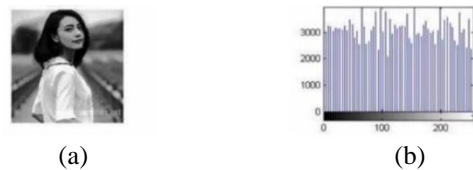


Fig. 3 Balanced effect and corresponding balanced histogram

3.3. Facial detection process

In the process of face detection, the main features of the face, such as eyes, mouth, or color, can be used for detection. After morphological processing, the target can be effectively segmented, and then each feature can be read, combined with PCA algorithm processing. The specific process is as follows:

Collect facial images using computer cameras or download facial images from websites. After image segmentation processing, the face image is obtained.

According to the requirements, perform facial region detection and collect partial feature data, such as facial color and other features. Collect facial features. Facial detection process is shown in Fig.4.

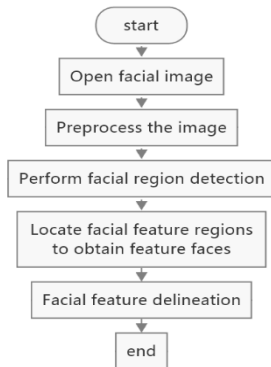


Fig. 4 Facial localization process

3.4. Face location

For the facial localization of this system, there may be multiple faces in one screen or other types of problems, which may mislead the collection of facial information.

Using a face detector to reduce the coefficient enables faster retrieval of faces in images. In the detection process, for possible multiple faces, the largest face is selected as the sample, and after the sample is captured, it is enlarged. Facial localization process is Fig.5.

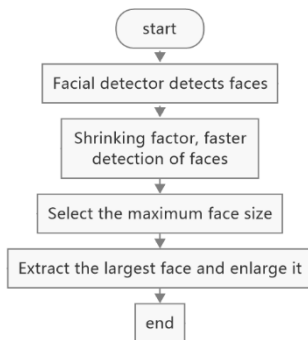


Fig. 5 Facial training sample library

Find the corner points in the detection area, where bbox is a matrix sequence. Form a rectangular box by framing the face, calculate the size of the rectangular box area, and select the maximum area rectangle as the face output.

3.5. Establishment of face training sample library

First, establish a TrainDatebase face training sample database, which can copy and paste foreign face samples. The same people try to choose several pictures with large differences, so that there is more room for future face selection. You can also use a computer camera to capture faces using a GUI interface. After that, image processing will be performed to enlarge the face, select suitable photos, and arrange them in the order of numbers 1, 2, 3, etc. into

the face training sample library. Facial training sample library is Fig.6.

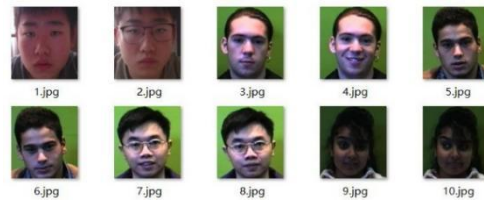


Fig.6 Facial detection process

3.6. Detailed process of image improvement based on PCA algorithm

For PCA, its basic idea can be understood as assuming that a set of 2D points shown in Fig.7 can be approximated as a single row, that is, the size of the points can be reduced from 2D to 1D.

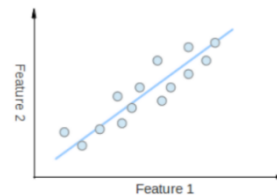


Fig. 7 2D point chart

We can see that these points change the most along the blue line, more than along the feature1 or feature2 axis. This means that if we can know the position of a point along the blue line, we have more information about that point than just knowing its position on the Feature1 or Feature2 axis.

The main optimization process of this system is to obtain the average vector of the sample, calculate the vector difference between each vector and the average vector, synthesize it into a feature matrix, and solve for the intelligent perception and feature vectors. Select the feature vectors for dimensionality reduction, and finally obtain the feature face.

Firstly, calculate the average vector of the sample, and its main formula is:

$$\bar{x} = \frac{1}{n} \sum_{\alpha=1}^n x_{(\alpha)} = (\bar{x}_1, \bar{x}_2, \dots, \bar{x}_p) \quad (5)$$

Calculate the difference vector between each sample and the average vector, subtract the average face from each sample, and finally combine the vectors into an n*n matrix.

After forming the matrix, calculate the covariance matrix, whose main formula is:

$$S \triangleq \sum_{\alpha=1}^n (X_{(\alpha)} - \bar{x})(X_{(\alpha)} - \bar{x})' = (S_{ij})_{p \times p} \quad (6)$$

Solve the eigenvectors and eigenvalues through the covariance matrix, select the eigenvectors, and finally perform dimensionality reduction to obtain the feature face. For eigenvectors and eigenvalues, it can be understood that

if A is an n-order square matrix and there exists a constant λ and a non-zero n-vector x, then

$$Ax = \lambda x \tag{7}$$

So λ is the eigenvalue of matrix A, and x is the eigenvector of A belonging to eigenvalue λ .

The comparison of the image before and after reconstruction is shown in Fig.8.

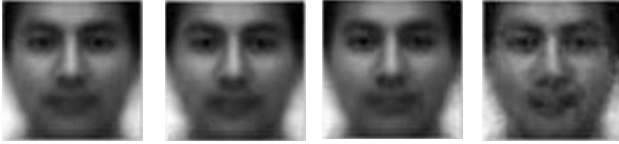


Fig. 8 Comparison of its image before and after reconstruction

3.7. Feature face matching based on euclidean distance

Euclidean metric (also known as Euclidean distance) is a common distance concept that refers to the true distance between two points in m-dimensional space, or the natural length of a vector (i.e. the distance between a point and the origin of coordinates). The Euclidean distance in 2D and 3D space is the true distance between two points. The two-dimensional formula is:

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \tag{8}$$

The three-dimensional formula is:

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \tag{9}$$

In n-dimensional space, two image matrices form a point, and then the Euclidean distance formula in mathematics is used to calculate the distance between the two points. The smallest distance is the most matching image. The process is shown in Fig.9.

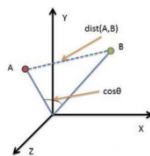


Fig. 9 Euclidean distance diagram

After combining the PCA algorithm with Euclidean distance. The process is shown in Fig.10.

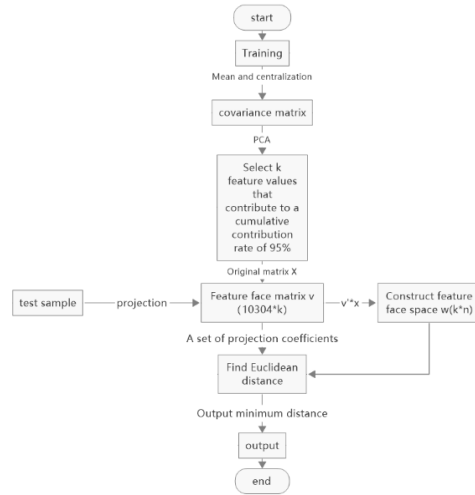


Fig. 10 Facial recognition and output flowchart

4. System design and simulation implementation

4.1. System detailed design

The recognition process of this system is shown in Fig.11, This system mainly has two modules, namely dynamic camera processing and static image processing.

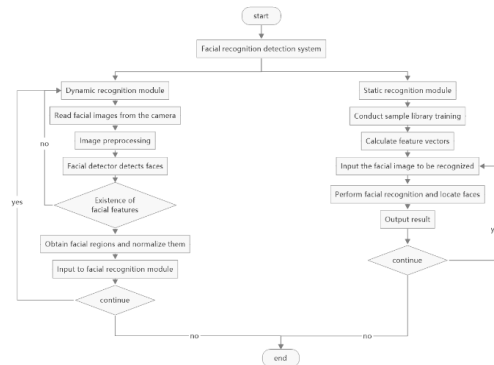


Fig. 11 Facial recognition detection system

4.2. Establishment of system GUI interface

The GUI interface of this system mainly includes facial recognition, positioning, testing, and camera shooting functions. After successful recognition, personal information will be displayed, such as class name, check-in times, check-in times, etc., and the check-in times of all people this week will be counted, which is shown in Fig.12.

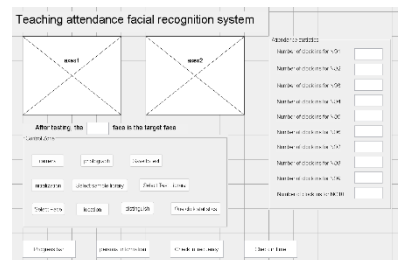


Fig.12 Initial GUI interface

4.3. Simulation results of the operation of each module in the system

Firstly, using the camera function of MATLAB, borrow a computer camera to take facial photos. After confirming the shooting, the image will enter the first box, which is shown in Fig.13.

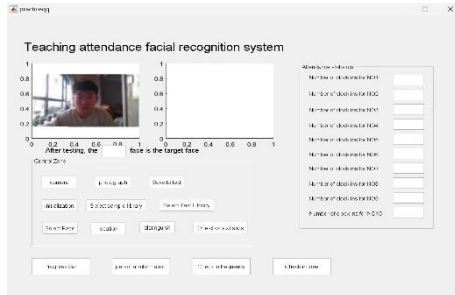


Fig.13 Shooting results

After shooting, click save to save it to the test data database. Then initialize the page and select the sample library for training, which involves extracting feature faces and identifying feature values. After successful training, it will prompt that the facial database training is complete, as shown in Fig.14.

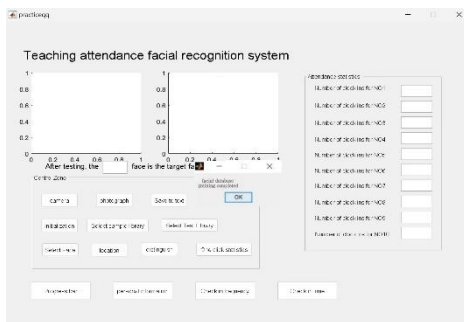


Fig.14 Sample library testing

Further test the test library. After all tests are completed, select the desired face and perform localization. The system will locate the face area based on the image. After clicking on recognition, the system will compare the face information contained in the image with the database and finally select the face that is closest to it. After recognition, a one click statistics will be performed, and the attendance count will be summarized on the right side of the diagram. Since the people recognized it once and it was number one, the system counted the number of clock ins as one. The final result is shown in Fig.15.

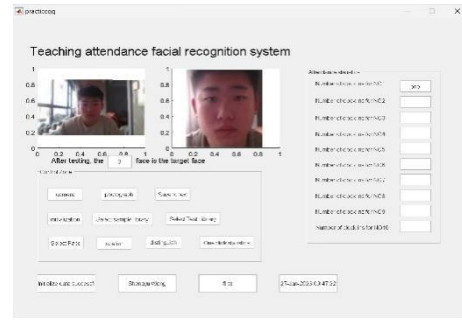


Fig.15 final result

The static recognition of ORL face database testing is also carried out in the same way. As shown in Fig.16.

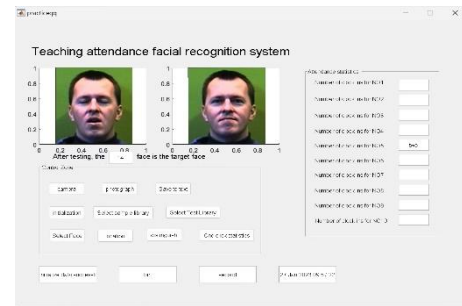


Fig.16 ORL facial database testing

5. Conclusion

According to the test results, there are also some incorrect recognitions, most of which are caused by extremely similar facial features. And due to the recognition accuracy of the PCA algorithm being only 85%, there may be a certain degree of error based on the component weights of each person in the sample library, which requires continuous testing.

Reference

1. Abd L S A ,Abdulelah A A ,Tahir S F A .Face Detection for Color Image Based on MATLAB.Journal of Physics: Conference Series,2021,1879(2).
2. Choudhary S ,Moriwal R ,Bansal S P D .Face Recognition System Based on PCA.Journal of Research in Science and Engineering,2020,2(11).
3. Yan X ,Xi Y ,Gaqiong L .Realization and optimization of face recognition system based on MATLAB.Journal of Physics: Conference Series,2020,1650(3):032091.

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