Face recognition algorithm based on open CV

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***Abstract*—With the rapid development of information technology and the continuous improvement of people's security awareness, people pay more and more attention to the research of face recognition. Open CV is an open source cross platform computer vision library, which realizes many common algorithms in image processing and computer vision. QT is a cross platform C++ GUI application development framework, which can be used to develop both GUI and non GUI programs. This paper first introduces the face recognition method. The process of face recognition includes three parts: face detection, face representation and face recognition. Secondly, the face recognition algorithm is studied, and PCA algorithm is used for face recognition. Then we use Visual Studio 2013 to build a face recognition system based on open CV, design the user interface with QT, and realize the face model detection and recognition training: open the image, carry out face detection and location, face feature annotation, and then open the second photo for recognition. At the same time, each module and the whole process of the system are tested, the test results are good, and a complete face detection and recognition system based on open CV is realized.**

Keywords—Face recognition, Open CV,PCA algorithm

I. INTRODUCTION

With the rapid development of Internet era and high technology, more and more people begin to pay attention to identity recognition. In the rich and colorful social environment, people will not encounter the problem of identity authentication all the time. Before, people usually use their student ID, driver's license, ID card to show their identity, because the card is easy to carry, so it was widely used. Nowadays, with the continuous development of high technology, science and technology have been widely used. These objects that were once relied on have been used and cheated by people, which not only cause harm to individuals, but also cause great losses to society. Therefore, it is important to find a safe and practical identification method.

It is found that the inherent physiological characteristics of human body have irreplaceable advantages, such as fingerprint, palmprint, facial features, expression and so on. They vary from person to person and will not change with time in a certain period of time. They are safe and reliable. Therefore, they are usually used as the object of academic research and practical application of identity authentication. As one of the most obvious features of human body, face has more obvious advantages than other human features: easy to obtain. With the camera, we can directly capture the distance of face images, so the popularity of face recognition technology in intelligent vision and intelligent learning is gradually increasing. From the current research of biometric recognition technology, the advantages of face recognition are: non-contact, in the process of obtaining the face image, the image acquisition device will not directly contact the user, this way is easier to be accepted by the user. Non mandatory, the collection of face image does not force the user to cooperate, and the face image can be obtained without the user's reaction. Concurrency, can collect and recognize multiple faces at the same time, more efficient. Simplicity. Face recognition does not require high equipment, only need to have an instrument with a camera to record the face image.Face recognition mainly aims to solve two problems, one is the identification of personal identity, the other is the identification of identity. Identity authentication is to confirm the user's identity information by matching, and identity confirmation is to confirm whether it is his identity information. The former is a one to many comparison, while the latter is a one to one comparison. The face feature recognition in this paper includes two parts: identification and identification. In this paper, identity authentication and identity confirmation are both called identity recognition. Face recognition usually refers to the use of related face recognition technology through the existing face database to achieve the purpose of face detection and recognition. Face recognition is mainly divided into three processes: face detection, face representation and face recognition [1,2,3].

Face detection includes three steps: face detection, face location and face tracking. Face detection is to determine whether there are faces or not through the acquired images, and to calculate the position and size of the face under some conditions. Face tracking is a real-time detection of face in a series of images. Face detection is easily affected by noise, illumination, camera parameters and occlusion. Face detection is also related to the accuracy of face representation and face recognition, so face detection is an important step in face feature recognition. In recent years, face detection has gradually developed into a separate research direction, and has attracted more and more attention of researchers.

Face representation is face feature extraction. The feature expression of face has both diversity and uniqueness. When extracting features, it is necessary to ensure that these two features can describe the face image accurately. Usually, the information of face image is very large. In order to improve the efficiency of the algorithm, we must do a dimension reduction processing for the acquired image.

Face recognition is to compare the face library to the face database, so as to get the similarity between the recognition

face and the original face characteristics. Face recognition is generally divided into face recognition and face recognition. Face recognition involves the processing of massive face data, so face recognition is more difficult than face recognition, and the calculation is also complex. In the massive face data processing, processing time and processing accuracy are the primary objectives, so the focus of face recognition is how to select the algorithm of face feature extraction and how to match to ensure the efficiency of the algorithm[4,5].

II. INTRODUCTION TO RELATED TECHNOLOGIES

A. face detection and location

- Principle of similarity calculation.

In data analysis, data mining and search engines, it is often necessary to know the size of individual differences, and then evaluate the similarity and category of individuals. Common such as data analysis, such as correlation analysis, data mining in the classification clustering (K-means, etc.) algorithm, search engine for item recommendation. Similarity is to compare the similarity of two things. Generally, by calculating the distance between the features of things, if the distance is small, then the similarity is large; If the distance is large, the similarity is small. For example, two kinds of fruits will be compared in terms of color, size, vitamin content and other characteristics. Common similarity calculation methods: Euclidean distance, Manhattan distance, Minkowski distance [6,7,8].

- Histogram principle.

Histogram is a graphical expression of the intensity distribution of pixels in an image. It counts the number of pixels in each intensity value. Histogram equalization is a method to enhance image contrast by stretching the intensity distribution of pixels. To be clear, take the image above as an example, you can see that the pixels are mainly concentrated on some intensity values in the middle. Histogram equalization is to stretch this range. Equalization means that one distribution (given histogram) is mapped to another distribution (a wider and more uniform intensity distribution), so the intensity distribution will be expanded in the whole range. To achieve the effect of equalization, the mapping function should be a cumulative distribution function [9,10,11]. For H(I) histogram, its cumulative distribution H '(I) is formula 1.

$$H^{'}(i) = \sum_{0 \le j < i} H(j) \tag{1}$$

To use it as a mapping function, we must normalize the cumulative distribution H'(i) with a maximum value of 255 (or the maximum intensity value of the image).

B. face feature annotation

- Principle of edge extraction

All along, when dealing with the problem of edge detection, we always take the convolution kernel, do a convolution operation with the original image, get the gradient value of each position, and then set a threshold to get the edge of the image. Gradient is a vector, which has both size and direction. It means that the directional derivative of a function at the point gets the maximum value (the modulus of gradient) along the direction (gradient direction), that is, it changes the fastest and the rate of change is the largest in the gradient direction [12]. For the image, the edge is the edge of the region where the gray level of the image changes sharply, because corresponding to the mathematical model, it is to find the point with a larger change rate, that is, the gradient modulus. If the modulus is greater than the threshold, it is a boundary, otherwise it is a contour. Summary: the mathematical meaning of edge detection: gradient based filter.

- The principle of marking face features

LBP refers to the local binary pattern, which is an operator used to describe the local features of an image. LBP features have significant advantages such as gray invariance and rotation invariance. LBP features are widely used in many fields of computer vision because of their simple calculation and good effect. The most famous application of LBP features is in face recognition and target detection. There are interfaces for face recognition using LBP features in open CV, an open source library of computer vision, and methods for training target detection classifiers using LBP features, Open CV implements the calculation of LBP features, but does not provide a separate interface for calculating LBP features.

C. PCA face recognition algorithm

PCA (principal component analysis), namely principal component analysis, is the most widely used data dimension reduction algorithm. The basic principle of PCA method: using the K-L transform to extract the main components of the face to form the feature face space, the test image is projected into this space to get a group of projection coefficients, and the recognition is carried out by comparing with each face image. It mainly includes two stages: training stage + recognition stage.

- Training phase

Step 1: Suppose that the training set has 10 samples, which are composed of grayscale images, and each sample size is M*N(ORL face resolution 92*112 = 10304). Write the training sample matrix:

Where vector x_i is the MN dimension vector stacked into a column by each column vector of the i image, that is, the matrix is quantized, as follows:

$$A = \left(X_1, X_2, \cdots, X_{10}\right)^{T} \tag{2}$$

If the i-th image matrix is $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$, then x_i is $\begin{bmatrix} 1 \\ 4 \\ 7 \\ 2 \\ 5 \\ 8 \\ 3 \\ 6 \\ 9 \end{bmatrix}$.

Step 2: Calculate the average face, calculate the average face of the training picture.

$$\Psi = \frac{1}{10} \sum_{i=1}^{i=10} X_i \tag{3}$$

Step 3: Calculate the difference face, and calculate the difference between each face and the average face.

Step 4: Construct covariance matrix.

$$d_i = X_i - \Psi, i = 1,2,\cdots,10 \quad (4)$$

$$C = \frac{1}{10}\sum_{i=1}^{10} d_i d_i^T = \frac{1}{10}BB^T \quad (5)$$

$$B = (d_1, d_2, \cdots, d_{10}) \quad (6)$$

Step 5:Find the eigenvalues and eigenvectors of the covariance matrix, and construct the eigenface space. If the dimension of the covariance matrix is MN*MN, when its dimension is large, the amount of calculation is large, so the singular value decomposition (SVD) theorem is used to obtain the eigenvalues and eigenvectors of AA^T by solving the eigenvalues and eigenvectors of A^TA. Contribution rate refers to the ratio of the sum of selected eigenvalues to the sum of all eigenvalues.

$$\phi = \frac{\sum_{i=1}^{i=p} \lambda_i}{i=200} \geqslant a \quad (7)$$

Step 6: Project the difference face vector between each face and average face into the "feature face" space, namely:

$$\Omega_i = w^T d_i (i = 1,2,\cdots,200) \quad (8)$$

- Identification phase

The first step is to project the difference face between the face image to be recognized and the average face into the feature space to obtain its feature vector representation.

$$\Omega^{\Gamma} = w^T(\Gamma - \Psi) \quad (9)$$

Step 2: define the threshold.

$$\theta = \frac{1}{2}\max_{i,j}\{\Omega_i - \Omega_j // \}i,j = 1,2,\cdots,200 \quad (10)$$

Step 3: use Euclidean distance to calculate the distance between Ω^{Γ} and each face.

$$\varepsilon_i^2 = \| \Omega_i - \Omega^{\Gamma} \|^2 (i = 1,2,\cdots,200) \quad (11)$$

III. PCA ALGORITHM FOUNDATION

The most basic concepts in statistics are the mean, variance and standard deviation of samples. Firstly, we give a set of n samples, and then we give the formula description of these concepts:

Mean value: $\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$ (12)

Standard deviation: $S = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n-1}}$ (13)

Variance: $S^2 = \frac{\sum_{i=1}^{n}(x_1 - \bar{X})^2}{n-1}$ (14)

The mean value describes the middle point of the sample set, which tells us that the information is limited, while the standard deviation describes the average distance between each sample point of the sample set and the mean value. Take these two sets as an example, [0, 8, 12, 20] and [8, 9, 11, 12]. The mean value of the two sets is 10, but obviously the difference between the two sets is very big. Calculate the standard deviation of the two sets, the former is 8.3, the latter is 1.8, obviously the latter is more concentrated, so the standard deviation is smaller. The standard deviation describes the "dispersion". The reason why we divide by n-1 instead of n is that we can better approximate the standard deviation of the population with a smaller sample set, which is the so-called "unbiased estimation" in statistics, and the variance is only the square of the standard deviation.

IV. FACE RECOGNITION SIMULATION BASED ON PCA

Open the face1 image, as shown in Figure 1.The similarity calculation, binary, vertical histogram, horizontal histogram ,facial region marking, edge extraction, eye marking, mouth marking and nose marking are performed successively for face images from top to bottom, as shown in Figure 2.

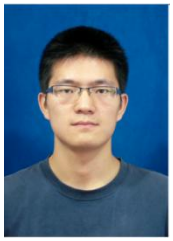
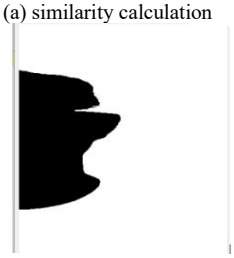


Figure 1. portrait image

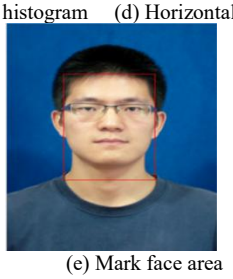
(a) similarity calculation

(b) binarization



(c)Vertical histogram

(d) Horizontal histogram



(e) Mark face area

(f) Edge extraction

(g) Mark eyes

(h) Mark the mouth

(i) Mark the nose

Figure 2. Face recognition of face1 image

Next, open face2, and the result is shown in Figure 3. The similarity calculation, binarization, vertical histogram, labeling face region, edge extraction, labeling eyes, nose and mouth are carried out from top to bottom, as shown in Figure 4. The eye, mouth and nose image information in the face images in Figure 3 and Figure 4 are compared and recognized. The experimental results can correctly recognize that two images are not the same face information, as shown in Figure 5.

V. CONCLUSION

Face recognition, as a cutting-edge technology, has become a hot research field, and has been widely used in many fields such as national security, certificate verification, information security, personnel attendance and so on. This paper summarizes the research status of face recognition, and describes the basic theory of PCA face recognition algorithm, and implements the algorithm with open CV open source visual library, and tests its performance. According to the test results, we decided to adopt PCA face recognition algorithm in the system, and build a face recognition system based on open CV by visual studio 2013. The system is tested, and a complete face recognition system based on open CV is realized, and the face recognition effect is good.

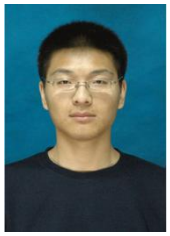


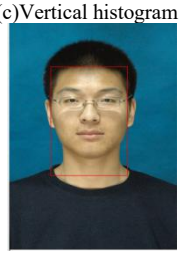
Figure 3. face2 image

(a) similarity calculation

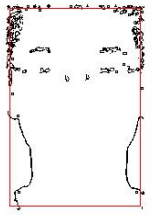
(b) binarization

(c)Vertical histogram

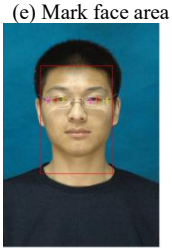
(d) Horizontal histogram



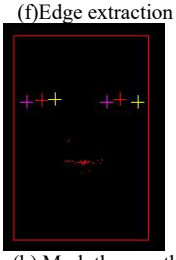
(e) Mark face area



(f)Edge extraction



(g) Mark eyes



(h) Mark the mouth

(i) Mark the nose

Figure 4. Face recognition of face2 image

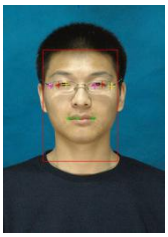


Figure 5. image comparison and recognition results

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