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# Batch Attendance System Based on Face Recognition

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**Abstract.** Biometric identification technology has been adopted to develop batch attendance system of electric power enterprises in this paper. The face is a typical biological characteristic, which can be adopted to promote the identity recognition efficiency without any touch. The face recognition technology includes three processes: face detection, face learning, and face recognition. The system has been deployed in Android platform, which has the highest market share of mobile operating system. The principal component analysis (PCA) has been adopted as the characteristic extraction method, and Java CV as the visual processing library. The experiment results show that the system achieves the higher accuracy with the more input photos and the fewer people in the photo, which helps the electric power enterprises to finish the staff attendance management.

## 1. Introduction

With the rapid development of science and technology, different ways of identity authentication make people's life style more convenient. The human brain is the most precise instrument, which enables us to identify thousands of things in nature through sound and appearance. However, the human brain is not almighty, it will fade away as time goes by, while computers not. They will process data in a specific way. Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals [1]. Biometric identifiers are often categorized as physiological versus behavioral characteristics. Physiological characteristics are related to the shape of the body. Examples include, but are not limited to fingerprint, palm veins, face recognition, DNA, palm print, hand geometry, iris recognition, retina and odour/scent. Behavioral characteristics are related to the pattern of behavior of a person, including but not limited to typing rhythm, gait, and voice. Some researchers have coined the term behaviometrics to describe the latter class of biometrics [2].

The knowledge-based characterization method has been adopted in this paper. It gets facial characteristic according to the shape of facial organs, and the distance between them. The facial organs includes chin, eyes, mouth, nose...and so on. They can be seen as the important characteristic of face recognition, as well as the structural relationship.

## 2. Related work

The research of face recognition started in the 60s of last century and develop slowly according to the scientific level. Since 80s, with the development of optical imaging technology, the accuracy of face



recognition has also been improved. The real application of face recognition is in the late 90 years. At that time, the United States and Japan did a lot of research in this area, and got a leading position in the world [3]. Face recognition has attracted much attention and gradually become the focus of research in computer science. Over the past thirty years, many technicians from various countries have done in-depth research on the knowledge of face recognition, and have drawn some important theories [4]. In the face recognition, the brain will make an impression on the whole and partial face. However, if there are some obvious partial characteristics, such as a nevus on the face, it will neglect the overall characteristics and focus on the local characteristics [5]. In the face recognition, the nose is a very interesting organ. When we see a man face to face, nose plays a very limited role in recognition; but when see from side, it play a more important role than any others. By twenty-first Century, the hardware level of computers has reached a whole new height. Face recognition is also beginning to be practical, with various recognition algorithms. In many famous universities such as Yale University, Massachusetts Institute of Technology and University of Manchester, face recognition project research laboratory has been established, and many achievements have been achieved. Especially, the "Eigenface" algorithm proposed by Professor Duke at Massachusetts Institute of Technology has been playing a very important role in the field of face recognition [6]. By the way, statistical learning theory represented by support vector machines [7], Face synthesis analysis technology based on 3D deformation, nonlinear modeling method and so on, gradually become the main research direction.

### **3. Face Recognition based on PCA**

#### *3.1. Introduction to PCA*

Principal component analysis (PCA) [8] is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. It is a statistical method, and its dimensionality reduction and characteristic extraction methods are widely applied in many areas, including face recognition. It adopts the K-L transform to extract data from the main parts of the face, which will be executed dimensionality reduction processing. It preserves the orthogonal basis of the high dimension image spatial which have the larger characteristic value, and forms the Eigenface space. The basic idea of the PCA is to solve the problem of a high dimension space in a low dimension space. In face recognition, it chooses a new image as the test use case, and projects the image into this space. Compared the projection coefficients with that of other faces. If the similarity is high, then shows that the target face belongs to this database, vice versa. PCA also has its own defects. It will recalculate the eigenvalues and eigenvectors of the entire library as soon as the new learning samples added to the database. It is no doubt a great amount of calculation when the database has many data. Comparing with other face recognition algorithms, the advantage of PCA is as following: 1) in the process of learning and recognition, nothing is required except face normalization; 2) There is no need for geometrical knowledge of faces, and characteristic extraction is relatively easy; 3) PCA decreases interference by reducing dimension, therefore it reduces the redundancy of original image, which facilitates image information reading in low dimension space; 4) PCA reduces the dimension of the image, so the operation speed is generally faster than others.

#### *3.2. Face Recognition Based on Eigenface*

Eigenface is a face recognition technology based on information theory and PCA, which can fast detect and recognize face characteristics. The operation of Eigenface is simple, generally applied on the system with low computing ability. Considering the hardware platform, Eigenface is adopted as the recognition algorithm in this system. It produced a two-dimension characteristic matrix set to describe the face, which avoid the three-dimension operations.

The K-L transformation [9] is based on the statistical characteristics. It behaves well in decorrelation. It is applied comprehensively in data compression technique, and it is the best transform method in the mean square error environment. K-L transform has theoretical guiding significance in

transform coding. It is easy to implement the "quasi optimal" coding method by finding some transformations which behave as well as the K-L transform.

Using the K-L transform, the system extract the face information to a 2 dimension matrix. Many face information was rebuilt with the weight set to get the characteristic image. When there is a new characteristic matrix, recognition can be threw by comparing the characteristic weights and the characteristic maps. The eigenface recognition includes training part and recognition part. In the training part, a group of images (it is 5 in this article) should be given. Train the group of images to get the eigenface data. When there are new faces to be trained, the training set will be updated, and the eigenface space should be calculated again. Project all the face images to the "eigenface space", calculate the correlation distribution of every face in M dimension space. In the recognition part, the new image will be projected to all the eigenfaces and operated to get the weight. Compare the weight with the original face set, the Euclidean distance will be get. Comparing the Euclidean distance with the defined threshold, it shows whether the face belongs to the "face space".

### 3.3. Operation Based on Eigenface

Find a set of vectors in the image space. Transform the original face image into an  $N^2$  vector. It is the eigenface vector (Eigen vector of the covariance matrix contains the original image). Get the M personal face images, and put the M vector in a collection S. It can be expressed as  $S=\{T_1, T_2, \dots, T_m\}$ . Add all the vectors in S, and calculate its average value, then get the average face. The average face is defined as follows:

$$\Psi = \frac{1}{M} \sum_{n=1}^M \Gamma_n$$

The difference between the image and a face is:

$$\Phi_i = \Gamma_i - \Psi$$

Find M standard vectors  $U_n$   $U_n$ , then the maximum eigenvalue corresponding to the Kth eigen vector can be denoted as:

$$\lambda_k = \frac{1}{M} \sum_{n=1}^M (u_k^T \Phi_n)^2$$

Because the M vectors in the formula are standard orthogonal vectors, therefore

$$u_l^T u_k = \delta_{lk} = \begin{cases} 1 & \text{if } l = k \\ 0 & \text{else} \end{cases}$$

Inside,  $u_k$  is the Eigen vector, and  $\lambda_k$  is the eigenvalue, then the covariance matrix  $C$  can be denoted as:

$$C = \frac{1}{M} \sum_{n=1}^M \Phi_n \Phi_n^T = AA^T$$

Inside, matrix  $A=[\Phi_1 \Phi_2 \dots \Phi_m]$ .

The operation to calculate the eigen vector and eigenvalue will cost a lot of resource, so the optimization is needed. Because the number of training images is much smaller than the dimension of

the image, e.g.  $M \ll N^2$ , it is not all the  $N^2$  eigenvectors that function in computation. In fact, because all the eigenvalues of other eigenvectors are 0, the function eigenvectors are only  $M-1$ . Thus the question is transformed into solving a  $N^2$  dimensional matrix  $L = A^T A$ , and the element at the  $m$ th row and the  $n$ th column can be denoted as:

$$L_{mn} = \Phi_m^T \Phi_n$$

The  $M$  dimension eigen vector of  $L$  can be calculated, which decides the linear combination of face image set. The eigen vector of covariance matrix can be denoted as:

$$u_l = \sum_{k=1}^M V_{lk} \Phi_k, l = 1, 2, \dots, M$$

At this point, the training part of face recognition is completed, and the eigen vectors suitable for facial expression can be obtained. Because the number of training images is much smaller than the dimension of the image, training set is relatively small, so as the operation of training.

When the new face image is input, it is projected onto the "face space" with the next formula:

$$\omega_k = u_k^T (\Gamma - \Psi)$$

Inside,  $k=1, 2, \dots, M$ . With this formula, the weight of the  $k$ th eigenface can be calculated. The  $M$  weights constitute a vector:

$$\Omega^T = [\omega_1, \omega_2, \dots, \omega_N]$$

This is how the eigenface represents the face. The next is to decide the best way to match the face.

$$\varepsilon_k^2 = (\Omega - \Omega_k)^2$$

Inside,  $\varepsilon^2$  is the Euclidean distance.  $\Omega$  is the weight vector of the face which to be recognized.  $\Omega_k$  is the weight vector of the  $k$ th face in the training set. If the minimum value  $\varepsilon^2$  is less than the threshold, then the image belongs to the face set  $k$ , otherwise not. The threshold is defined according to the training set.

The process of face recognition is shown as figure 1.

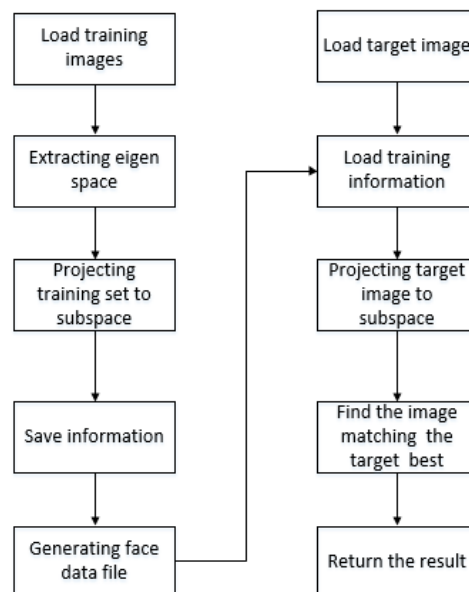


**Figure 1.** Implementation of eigenface algorithm

### 3.4. Design of Batch Attendance System Based on Face Recognition

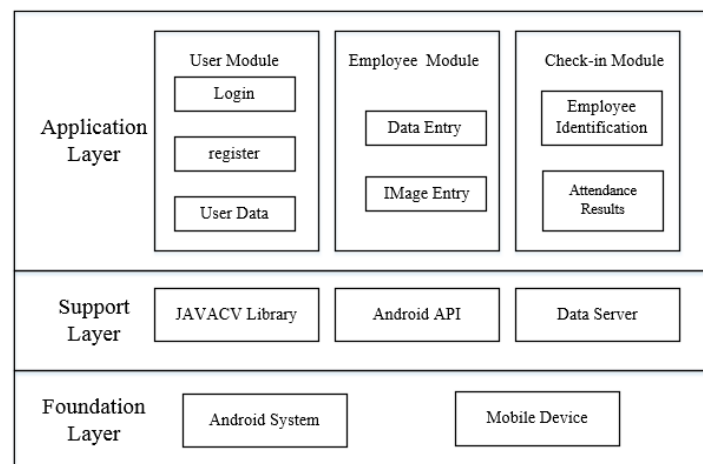


**Figure 2.** Function structure of batch attendance system

Batch attendance system based on face recognition consists of foundation layer, support layer and application layer. The foundation layer is the base of program operation, including Android operating system and the mobile hardware. The support layer is the guarantee of program operation, including JavaCV library, Android API and data server. The JavaCV library provides the function of face learning and recognition. Android API provides the basic functions and settings for the Android program, and the data server provides data support for the system. The application layer includes user module, add staff module, and check-in module.

## 4. Experiment and analysis

In order to test the batch attendance system based on face recognition, a number of different tests have been thrown with the face recognition algorithm based on PCA. The number of participants in this test is 100. Every participant cast 10 times tests. The result is shown in table 1.

**Table 1.** Face recognition accuracy

| Training photos per person | Face number in a photo | accuracy |
|----------------------------|------------------------|----------|
| 1                          | 1                      | 50%      |
| 3                          | 1                      | 85%      |
| 5                          | 1                      | 95%      |
| 7                          | 1                      | 97%      |
| 10                         | 1                      | 99.7%    |
| 5                          | 1                      | 95%      |
| 5                          | 2                      | 93%      |
| 5                          | 5                      | 88%      |
| 5                          | 7                      | 83%      |
| 5                          | 10                     | 80%      |

The test results show that the more photos people input, the higher the accuracy of face recognition can get. The more faces on each photos, the lower the accuracy of face recognition become. As a whole, the attendance system based on face recognition basically achieves the expected goal, but the accuracy of face recognition still needs to be improved.

## 5. Results

The system developed in this paper can achieve the requirement of face recognition. It was successfully implemented on the Android platform, after rebuilding and optimizing the technology originally designed to apply in the PC. In order to solve the problem of insufficient computing power of Android platform, a method to reduce image size is proposed. This method will decrease the accuracy of face recognition, but considering the photo quality and computing ability of the mobile phone, it will benefit the face recognition on the whole. The system can be applied in most smart phones on the market. Although some achievements have been made in this paper, face recognition technology has just started to apply on the Android platform, so there is still room for improvement.

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