Research on Mobile Payment Recognition Technology Based on Face Detection Algorithm

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Abstract — Object: With the development of science and technology, and the growing popularity of online shopping and mobile banking, mobile phones have a wide application prospect and development space. However, the security problem of mobile phone based on online payment is the primary problem that people have to consider in the process of using. Method: Therefore, this paper proposes the mobile payment recognition technology based on face detection algorithm. Process: Based on the analysis and comparison of the existing classical face detection methods, this paper presents a better detection method, and gives the single sample face recognition based on image singular value decomposition, then puts forward the practical mobile face recognition system, and makes a detailed description of the function of the scheme of each part. Conclusion: The simulation experiment results show that this method not only can achieve the needs of the comparative methods, but also decrease the time complexity of computing.

Keywords - Face recognition; mobile phone; face detection; principal component analysis; wavelet decomposition

I. INTRODUCTION

With the development of social economy and science and technology, the role of mobile phones is similar to the personal computers in people's lives, which also have a wide application prospect and development space. At the same time, [1] with the growing popularity of e-commerce, online shopping business, it has become an inevitable trend of the development of the mobile phone to add the authentication function based on biological characteristics. In general, although the phone itself has the functions of setting numeric password and the SIM card lock, which makes it guarantee the safety of mobile phone in a certain extent, but with the emergence and development of mobile banking, mobile shopping and other new applications, more and more people buy goods and services through the convenient and fast channel, based on this, the potential safety problems become more and more prominent. In order to increase the safety of mobile phone, the use of complex password or password string becomes the common method used in the current transaction. Based on the outstanding advantages of face recognition, in recent years, people have tried to embed face recognition technology to the PDA, [2] mobile phones and other mobile devices with the function of camera, so as to achieve the identity confirmation of users through the facial feature recognition and protect the safety of mobile phone in the process of use [3].

Therefore, this paper proposes the mobile payment recognition technology based on face detection algorithm. Based on the analysis and comparison of the existing classical face detection methods, this paper presents a better detection method, gives the single sample face recognition based on image singular value decomposition through the comparison of principal component analysis method and Gabor filtering method of single face recognition, then puts forward the practical mobile face recognition system on the basis of the specific application of face recognition of mobile phone, and makes a detailed description of the function of the scheme of each part. The simulation experiment results show that this method can achieve the needs of the comparative methods [4].

II. RESEARCH STATUS

At present, the application of face recognition technology in the mobile phone technology platform has some useful methods, but because of the phone itself limitation in the storage and the computational speed, therefore, the face recognition algorithms that have occupy larger storage space can’t be used in mobile phone system, which also makes the mobile face recognition technology have many problems. In early stage of face recognition of mobile phone, Shibnath Mukherjeet proposed the use of face authentication method based on feature model in mobile devices. Although the requirement of storage capacity and computing power of this method was high, but it also opened up a new direction for the development of this field. At the same time, the face location technology was applied to mobile devices (such as N93i Nokia and N81 Nokia 0, etc.). In addition, as other face detection methods, the face detection method based on skin color model was also presented and used for mobile phone platforms. Due to the impact of illumination change on face recognition, Paolo Abcni, Sung.UK respectively introduced the application of face recognition to the larger face image. Based on the real-time problem in the process of mobile face recognition, the feature extraction and classification recognition method based on visual salience
and neural network was also put forward. In the bio metric identification technology, multi modal identification methods are the hot research topics. Based on the joint efforts of the researchers, the British Manchester University first public exhibited the world's first face recognition and verification software that can be implanted in mobile phone in 2010, [5] which opened up a new way for the application of face recognition technology in the mobile platform, at the same time, shortened the mature time of the technology [6].

III. RELATED FACE DETECTIONS

A. Mobile Phone Face Detection

In general, the face recognition technology in bio metric identification technology is mainly divided into two stages: face detection and face recognition. Face detection technology refers to the process that defining the number of involved face and identifying location, [7] size, pose of all faces under the circumstances of detecting the input image whether contains the face. As the relatively new application areas of face recognition, the research and development of mobile face recognition technology is slowly because of a variety of practical problems. The face detection methods that applied to the field mostly are the improvement and integration based on the traditional method. Firstly, this paper gives classification to the existing face detection methods.

Figure 1 Mobile phone face detection

Face detection based on template matching

The face detection method on the basis of the template matching gets a frontal face as the standard face template in template matching through the artificial predefined or the parametric function. For the given input image, through calculating the related values of face, eyes, nose and mouth in the standard face model and the input image, the conclusion that whether includes the face is obtained according to the income correlation value [8].

Face detection based on feature space

The face detection method based on feature space judges the face pattern by finding the invariant features of human faces. The method of principal component analysis (PCA) is earlier used for face detection method based on feature space, which can remove larger correlation between the non face samples, thus preserve the clustering among the face images [9].

Face detection based on neural network

The face detection based on neural network judges the final results by directly using one or more neural network in every part of the input image, so as to achieve the purpose of determinate whether the input image is the face sample set [10].

Face detection based on Boosting

Boosting lifting scheme is a general learning algorithm, which can effectively improve the performance of the algorithm. The classification method based on boosting is earliest used in the gambling with binary nature, and the main idea of which is from the probably approximately correct theory.

Face detection based on skin color model

Due to the computational complexity is low, the face detection based on skin color model gets the attention of researchers. In general, according to the process of the involved imaging, the method of face detection based on skin color can be divided into two basic types: The method based on the artistic and the method based on the physics [11].

B. Performance Evaluation Index of Face Detection

At present, the indicators widely used in the evaluation of the performance of face detection algorithms include: Rate detection: This indicator is the most important indicator of the evaluation of face detection system performance, it indicates the ratio between the number of images and the total number of faces in the images that correctly detected; False rejection rate: It refers to the ratio between the number of images and the total number of faces in the images that not be detected; False detection rate: It refers to the ratio between the number of images and the total number of faces in the images that wrongly detected. In addition, there are the detection speed and detection accuracy.

C. Comparison and Analysis of the Face Detection Algorithms

In this paper, the above four kinds of commonly used face detection methods are validated and compared. The comparison results of each detection method as shown blow.

<table>
<thead>
<tr>
<th>Face detection methods</th>
<th>Detection rate</th>
<th>Required time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural network</td>
<td>0.9536</td>
<td>2.1720</td>
</tr>
<tr>
<td>Support Vector Machine</td>
<td>0.9980</td>
<td>0.5310</td>
</tr>
<tr>
<td>Adaboost method</td>
<td>0.9989</td>
<td>2.3082</td>
</tr>
<tr>
<td>Skin color model</td>
<td>0.9982</td>
<td>0.7180</td>
</tr>
</tbody>
</table>
As shown in the table, it can be seen that using different classical face detection method to detect the human face image face database of mobile phone can get better detection effect, but these detection methods also have some defects. Considering the detection rate, the cost of time consumption, algorithm adaptability and the complexity of training sample set selection, the face images used in the process of face recognition in this paper are detected on the basis of the skin color model detection method [12].

IV. SINGLE SAMPLE FACE RECOGNITION BASED ON IMAGE SINGULAR VALUE DECOMPOSITION

A. Principal Component Analysis

In the face recognition, principal component analysis (PCA) method has been considered to be the classical subspace method that used in the field of pattern recognition and computer vision to carry on the feature extraction and dimensionality reduction. It is a statistical theory method based on K-L transform. The implementation procedure is as follows:

Given input training sample set: $x_1, x_2, ..., x_N$, in which, $N$ is the number of the training face, the size of each face image is $m \times n$, each face image is transformed into $m \times n$ size vector;

Seeking the average face image vector of training samples:

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i$$

(1)

Normalization of each face image: $\varphi_j = x_i - \bar{x}$

Calculating the co-variance matrix of the face image:

$$C = \frac{1}{N} \sum_{i=1}^{N} \varphi_i \times \varphi_i^T$$

(2)

Eigenvalues decomposition of co-covariance matrix is obtained in (4):

$$\varphi_i^T \times \varphi_i = \mu_i \times \varphi_i$$

(4)

Carrying on the descending sort to the characteristics of the type of values in (5), and then selecting the feature vectors $\varphi_1, \varphi_2, ..., \varphi_M$ that corresponding to the largest eigenvalues of the former $M$ to constitute a matrix, so as to regard it as the projection feature subspace of the face:

Mapping each training face image to the projection feature subspace:

$$r_i = \varphi_i \times (x_i - \bar{x}), i = 1, 2, ..., N$$

(5)

When testing, the test face image is normalized by the use of (2), then, the normalized face image vector is projected into the subspace, so the projection vector is obtained after dimension reduction, finally, the similarity of the face image is got by calculating the euclidean distance between the test image and the training image. According to the criterion of minimum euclidean distance, the classification and recognition are carried out.

B. Method Based on Singular Value Decomposition

Singular value decomposition (SVD) is a kind of matrix decomposition theory that widely used in linear algebra. Its purpose is to carry on the dimensionality reduction to the sample which includes a large amount of data so as to obtain the process that contains the less but more important features. As a data analysis method, the singular value decomposition can be used to obtain a large quantity of data implied information. Due to the decomposition of singular value is arranged on the basis of the size of order, so it can directly abandon those adverse part of singular value features that have little or bad impact on face recognition, so as to retain the positive characteristics that have a greater impact on the face recognition. For the face image $A$ with the size of $m \times n$, the singular value decomposition of $A$ can be obtained:

$$[U, D, V^T] = SVD (A)$$

Among them, $U, D, V$ respectively indicate the matrix with the size of $m \times n, n \times n, n \times n$, and the diagonal matrix $U, V$ are the normalized matrix. diagonal matrix $D$ is a semi positive definite diagonal matrix, the size of the diagonal elements is in descending order, the elements $D_{i,j}$ of diagonal on the diagonal matrix $D$ the is called the singular value of the image matrix. At the same time, rank $(D) = rank (A)$, that is, the diagonal matrix $D$ and the image matrix $A$ have the same rank. Then, the diagonal matrix $D$ of the singular value decomposition of the given image matrix $A$ is uniquely determined. And the singular value decomposition meets:

$$A = U \times D \times V^T = U_{m \times n} \times D_{n \times n} \times V_{n \times n}^T$$

(7)

Based on this, we can carry on the approximate reconstruction to the original face image according to the partial singular value of the singular value decomposition of the human face image and the product of the corresponding vector:

$$A_i = \hat{\lambda}_i \times \mu_i \times v_i^T + \hat{\lambda}_i \times \mu_i \times v_i^T$$

(8)

$$A_2 = \hat{\lambda}_2 \times \mu_i \times v_i^T + \hat{\lambda}_2 \times \mu_i \times v_i^T$$

(9)

$$A_3 = \hat{\lambda}_3 \times \mu_i \times v_i^T + \hat{\lambda}_3 \times \mu_i \times v_i^T$$

(10)

In the above reconstruction, $\mu_i, v_i, \hat{\lambda}_i$ respectively indicates the transpose of first column of $U$, the transpose of first column of $V$ and the diagonal elements in the diagonal matrix $D$. This method can retain most of the useful information in face recognition and removal the interference that caused by all sorts of reason on the face recognition.

C. Method Based on Gabor Filtering

The changes of illumination, facial expression and the changes of posture lead to the complex deformation, which has great influence on the face recognition. In theory, the Gabor wavelet has the Fourier transform of the window with the most hour window. The Gabor wavelet has good directionality selectivity in the spatial domain and also has good frequency selectivity in the frequency domain, so which can comprehensively include all directions of local
information of the face, therefore which is widely used in the face representation. In the time domain, the two-dimensional Gabor filter is composed of sine function of Gauss function modulation. At this time, because five scales and eight orientations of Gabor filters is used to denote the single sample face image, which increases the training face images in different directions at different scales of some useful information.

D. Single Sample Face Recognition Based on Image Singular Value Decomposition

During the face recognition, the changes of expression and rotation of the face image have a great impact on the recognition results, especially for the single sample face recognition. Due to there are not too much training face samples can be referenced, so when the recognition is carried out if the test face image has a small angle deflection relative to training face samples, which is also bound to affect the effect of the late face recognition. Therefore, this paper uses the single sample face recognition method based on the image singular value decomposition to solve part of problems of the face image rotating. This paper uses the principal component analysis method based on directional two dimensional to extract the features of mobile phone face image after image singular value decomposition. The block diagram of the algorithm is shown in Figure 2:

![Figure 2 Block Diagram of Algorithm](image_url)

E. Design of Mobile Phone Face Recognition System

Through the above introduction and analysis, this paper identifies the solution of face detection and face recognition system that applied in mobile phone platform. In order to facilitate the application of the technology, the whole mobile face recognition system can be used as a practical software development and implementation, and then the download and install channels can be provided for the users according to the different application requirements, at the same time, the mobile face recognition system also can be embedded and solidified into the intelligent machine. Based on the above discussion, we can design the overall implementation process of the mobile phone software. Figure 3 describes the implementation process of the system block diagram.

![Figure 3 Block diagram of cell phone face recognition](image_url)

From Figure2, we can see that the face recognition system mainly divided into the registration, password settings, face detection and authentication of mobile phone owners of the mobile phone owner sample image, the following will be introduced separately to these three parts, details are as follows:

Password settings and user registration

This process is mainly used for the identity of the registration and password setting when the mobile phone host first uses the phone. Password setting is good for the auxiliary method when the mobile phone users can’t use the face image to verify in the following. The face image registration process can achieve the role of the storage of mobile phone owners face image and the image characteristics of the face samples. The host image features are preserved in the surface characteristics of the image, which facilitates the comparison with the classification and recognition of images in the authentication process. Block diagram of the process is shown in Figure 3.

Face detection

This paper uses the face detection method based on skin color model to carry on the segmentation and calibration through the face region in the face detection stage, the pending examination face images are detected in real-time, which lies the foundation for the subsequent face recognition.
V. EXPERIMENTAL SIMULATION ANALYSIS

In following experiment data, a picture that arbitrarily selected from each class of face images in the face database is regarded as the training sample, another nine pictures is regarded as the test samples, and the experiment result of each group is the average result of five experimental results obtained from the random sampling process. Figure 5 represents the results curve of single sample face recognition by using two-dimensional PCA method in different image size of face image, where the reduction process is in a row direction; Figure 6 represents the results curve of the single sample face recognition by using the Gabor filters based on five scales and eight orientations. In which the Gabor filter group is used to represent the face image, the next sampling factor is 8; At the same time, in order to compare the adaptability of the common single sample face recognition method to mobile phone face database that introduced in this paper, Table II describes the recognition accuracy of different single sample face recognition methods in achieving the best recognition results and the time required to recognize each face image.

VI. CONCLUSION

With the widespread application of mobile phone in people's life, all kinds of security problems of mobile phone are becoming increasingly prominent. Based on the analysis of mobile face recognition research status, this paper mainly carries out research, analysis and discussion to the face recognition technology based on mobile terminal on the following contents: This paper introduces the existing face detection methods, and analyzes and compares the common methods of face detection in detail, then this paper proposes the single sample face recognition method based on image singular value, and compares with the subspace method and the single sample face recognition method based on Gabor filter. So, based on the practical application of engineering, a practical mobile phone face recognition system is designed. The simulation experiment results show that this method not only can

![Figure 4 Face detection](image1)

![Figure 5 Single sample 2DPCA recognition result](image2)

![Figure 6 Gabor transformation result](image3)

**TABLE II. PERFORMANCE COMPARISON OF DIFFERENT METHODS**

<table>
<thead>
<tr>
<th>The method</th>
<th>PCA</th>
<th>2DPCA</th>
<th>Gabor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognition time (s)</td>
<td>1.756</td>
<td>4.379</td>
<td>1.205</td>
</tr>
<tr>
<td>Highest recognition rate</td>
<td>0.7994</td>
<td>0.7908</td>
<td>0.7690</td>
</tr>
</tbody>
</table>

Analysis of simulation result

Through the above recognition graph of each single sample face recognition method can be seen that the traditional method of face recognition based on subspace identification in the single training sample has little difference in recognition accuracy. But compared with the principal component analysis method, the two-dimensional principal component analysis method needs more coefficients in the storage, so the requirement of storage space is needed to be higher. Thus, the recognition time is also increased; And from Table 2 can be seen, compared with other single sample face recognition methods, the single sample face recognition method based on the image singular value decomposition used in this paper improves the accuracy of single sample face recognition but doesn’t greatly identify the time complexity.
achieve the needs of the comparative methods, but also decrease the time complexity of computing. However, although the face recognition method that proposed in this paper can get good recognition effect for mobile phones face image database, but because the implementation process is on the basis of PC simulation, so the complete implant of face recognition process in the mobile phone terminal still face many problems.

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REFERENCES