Research of Face Recognition Method Use of MRA-Framework

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***Abstract*—Of the face image after adding noise, face recognition rate of traditional PCA method will be significantly lowered, this paper will use orthogonal wavelet + PCA and wavelet frame + PCA methods to study it respectively. First, the face image processing plus noise, then decomposition the image under the use of orthogonal wavelet and wavelet frame, and then sub-graph of decomposition will be dimensionality reduction and feature extraction using the methods of PCA, and finally, use third-order nearest neighbor classifier for classification and identification. And on the ORL face database, the experiment results show the effectiveness of this method, good way to improve the recognition rate plus noise situation servants face image.**

Keywords-face recognition; MRA-framelet; principal component analysis (PCA); wavelet transformation; noise adding

I. INTRODUCTION

As a issue both of theoretical value and application value, face recognition have applied to become a hot topic of the current pattern recognition and computer vision [1, 2], more and more attention by researchers and concern. Over the past few decades, people have put forward a lot of classical methods, principal component analysis [3, 4] (PCA) method is the most basic and also the longest appear recognition method, the current face recognition algorithms are a lot of improve of this method or integrated with other methods, because of its effectiveness in dimensionality reduction and feature extraction of face recognition, it has been widely used. But the image in process of formed, recording, processing and transmission, due to the difference of imaging system, recording equipment, transmission medium, and imperfect processing method, it will lead to the image quality decline, and the noise is an important element in causing image degradation. The inclusion in the face image noise not only makes image quality, but also affected the image of the visual effects, and research finds it also greatly reduce the traditional PCA Face recognition results.

The wavelet transform is a time-frequency analysis tool developed in the 1980s, After Mallet [5] put forward a fast decomposition algorithm isnproposed, and the algorithm has been successfully used in image processing field. This paper using wavelet transform + PCA method was studied based on the traditional PCA And on the ORL face databases were experimental; the results demonstrate the effectiveness of this method.

In different applications, both expect to find compactly supported wavelets have a symmetric (or ant symmetric) nature, there are many ways to make wavelet have symmetry, for example, abandon wavelet symmetry, or consider multiwavelet. Fortunately, wavelet frame is also a good solution to this problem, wavelet frame and orthogonal wavelets are two main components of the discrete wavelet transform, they are simultaneously development. In image processing, wavelet frame and orthogonal wavelets have the same computational complexity, however, wavelet frame can not only overcome the shortcoming of orthogonal wavelet ,and increased the appropriate redundancy, Not only retains the properties of all except orthogonal wavelet, and easier to construct than the orthogonal wavelet. Therefore, this article focuses on research of wavelet framework and PCA method of face recognition.

II. FRAMEWORK

A. The Relevant Concepts of Framework

Framework is the concept put forward by R.I.D uffinA. And G.S chaeffer in the nonharmonic Fourier series of 1952, it is a generalization of the concept of standard orthogonal basis. Framework still can represents separable tools of Hilbert space element as same as the basal, except that framework does not require the elements of linear independence.

Definition 1[7] In Hilbert space a family of functions $\{g_j\}, j \in Z$, if $0 < A < B < \infty$, for all $f \in H$, then:

$$A\| f \|_2^2 \le \sum_{j,k\in Z} | f, g_j >|^2 \le B\| f \|_2^2 \qquad (1)$$

Then the collection of $\{g_j\}$ is called a frame, constant A, B called frame boundary.

If $A = B$, then called tight frame. In particular, if $A = B = 1$, $\{g_j\}$ is called Parseval frame.

When $H = L^2(R)$, considering the collection $X(\psi)$.

When $H = L^2(R)$, considering the collection $X(\psi)$, $X(\psi) = \{\psi_{j,k} : \psi \in \Psi; j,k \in Z\}$, where: $\psi = \{\psi^1, \psi^2, \cdots, \psi^r\}$, $\psi_{j,k}(y) = 2^{j/2}\psi(2^j y - k)$.

Definition 2[6] Let $X(\psi) \subset L^2(R)$, When $X(\psi)$ is a framelet of $L^2(R)$ space, that is, for all $f \subset L^2(R)$ satisfy

$$A\| f \|_2^2 \le \sum_{1}^{r} \sum_{j,k\in Z} |< f, \psi_{j,k}^i >|^2 \le B\| f \|_2^2 \tag{2}$$

$X(\psi)$ s called a wavelet frame of $L^2(R)$, Each element in collection $\psi = \{\psi^1, \psi^2, \cdots, \psi^r\}$ is a generator of the framework. Similarly, when $A = B$, it is called tight wavelet frame. When $A = B = 1$ $X(\psi)$, it is called tight Parseval frame.

Definition 3[7] In Hilbert space, if there is an MRA (multi-resolution analysis), satisfy $\psi \subset V_1$, then the Parseval frame called MRA-Parseval frame, referred MRA-framework.

Hypothesis MRA $\{V_j, j \in Z\}$ is generated with Compactly Supported scaling function ϕ, and satisfy the scale equation

$$\varphi(x) = \sum_{k\in Z} p_k \varphi(2x - \mathrm{k}) \tag{3}$$

Then the finite sequence is a filter of scaling function ϕ, called a low-pass filter.

MRA- framework $\psi = \{\psi^1, \psi^2, \cdots, \psi^r\} \subset V_1$, consisting of a Parseval frame of $L^2(R)$, correspond, each frame generators satisfy the two scale equation:

$$\psi^{\mathrm{i}}(x) = \sum_{k\in Z} q_k^i \varphi(2x - k), i = 1, 2, \ldots r \tag{4}$$

Then the finite sequence $\{q_k^i; N_1^i \le k \le N_2^i\}$ is a filter of the frame generator ψ^i, called a high-pass filter.

B. The Choice Of Framework In This Article

At present, many scholars have set their sights on wavelet frame. In 2000, CKChui Study corresponding to the compact support Refinable functions of compactly supported tight framework $\psi = \{\psi^1, \psi^2, \cdots, \psi^r\}$. Gives a necessary and sufficient conditions for the exits of Ψ: just add thin Laurent polynomial function symbols satisfy an inequality $(|P(z)|^2 + |P(-z)|^2 \le 1)$,. he also discussed the decomposition and reconstruction algorithm of wavelet framework [7].Later I. Daubechies, CKChui, Bin Han and others have also put forward a number of methods and good nature [10-14] .In 2013, Bin Han also used oblique extension principle (OEP) to construct a symmetric tight wavelet frame, Structure have been obtained respectively with two symmetrical tight frame filter high-pass filter group and has three symmetrical tight frame filter high-pass filter [8,9]. This algorithm is simpler than before the method [7, 10-14].

This article refers to the literature [8] example three constructed tight frame filter bank which have two high-pass filters: For the scaling function ϕ, corresponding to two scale symbol is:

$$P(z) = -\frac{3}{64}z^{-2} + \frac{5}{64}z^{-1} + \frac{15}{32} + \frac{15}{32}z + \frac{5}{64}z^2 - \frac{3}{64}z^3 \tag{5}$$

$$Q_1(z) = \frac{1}{16}z^{-2}(z-1)^3(3 + 4z + 3z^2) \tag{6}$$

$$Q_2(z) = \frac{\sqrt{15}}{16}(1 - z^{-1})^2(1 + z)(3 - 2z + 3z^2) \tag{7}$$

Then $\{P; Q_1, Q_2\}_\theta$, where $\theta = \delta$ is a symmetrically tight frame filter bank with two high-pass filter.

The filters P, Q_1, Q_2, refinable function (scale function) ϕ, and the generator ψ_1, ψ_2 of MRA-frame $\Psi' = (\psi_1', \psi_2')$ are shown in Figure 1.

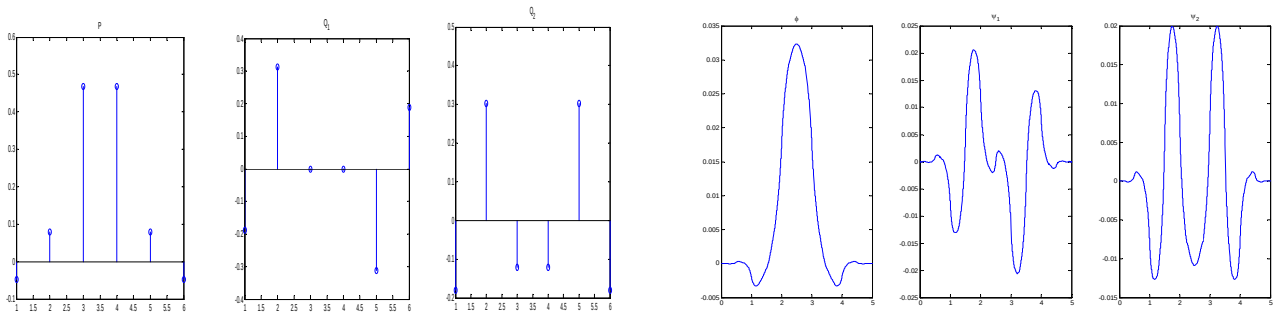

FIGURE I. IMAGE FRAME FUNCTION

III. PCA ANALYSIS

A. The Design Of Fast PCA Recognition Algorithm

The most important work of PCA calculation is to calculate eigenvalues and eigenvectors of the sample covariance matrix (scatter matrix)

$$S_t = \frac{1}{n}(X - \overline{X})(X - \overline{X})^T = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)(x_i - \mu)^T \tag{8}$$

Hypothesis the size of sample matrix X is $n \times d$ (n one-dimensional sample vector), in the face recognition in this article $n = 40 \times 5 = 200$, $d = 112 \times 92 = 10304$ .then covariance matrix S_t will be a $d \times d$ square matrix ,so when the dimensioned is large, direct calculation is quite difficult, to get all the characteristics of the sample covariance matrix of values may take a long time. So we can take the quick PCA algorithm.

Hypothesis $Z_{n\times d}$ matrix is a sample matrix X in each sample after subtracting the matrix sample mean , then scatter matrix s is $(Z^T Z)_{d\times d}$, Now consider the matrix $R = (ZZ^T)_{n\times n}$, they have the same non-zero eigenvalues, So we can directly obtain the corresponding eigenvalues of S by calculating the eigenvalues of R .

Hypothesis n-dimensional column vector v is the characteristic vector corresponding eigenvalues λ of R , then:

$$(ZZ^T)\ v = \lambda v \tag{9}$$

For the above equation (19), on both sides simultaneously multiplying Z^T , and application combining matrix multiplication law can be obtained:

$$(Z^T Z)(Z^T v) = \lambda(Z^T v) \tag{10}$$

We can calculate the small matrix $R = (Z^T Z)_{n\times n}$ d eigenvectors v , then premultiplying Z^T indirectly scatter matrix eigenvectors $S = (Z^T Z)_{d\times d}$. This approach can greatly reduce the use of traditional PCA algorithm computation, improve computing speed.

IV. SIMULATION AND ALGORITHMIC PROCESS

A. Simulation Environment

Experimental use Matlab 2010a programming, Use the ORL Face library from Cambridge Olivetti laboratory as data collection, the database contains 40 individuals, everyone has 10 images, total 400 images, each image has 256 gray levels, all of the size are 112×92, Everyone will be divided into two groups in the database, the first five constituted the training set, the other 5 constituting the test set. The training sets and test sets have 200 people face image samples. Part of the face image shown in Figure 2.

FIGURE II. LEGEND OF ORL FACE DATABASE OF PEOPLE FACE

B. Algorithmic Process

1) Scheme I: The traditional PCA method

a) Reads the image

The ORL face database of 400 face images were divided into a training set and test set and the training set of 200 faces images were read in.

b) Fast PCA algorithm to extract facial feature

Take use of Fast PCA algorithm for image dimension reduction tonremove the correlation between pixels. Extract Principal components from the training samples, and then complete the conversion by the projection base. In subsequent experiments to reduce feature vector dimensionality to represent the human face samples. Similarly, the use of fast PCA algorithm can also get the main component of the training set face.

c) Classifier

In Experiment third-order neighbor was selected as classifier. The third-order neighbor classification is better than the Euclidean distance (Euclidean distance) classification. And it is projected to be different from the weighting process, thus will improve the recognition effect, which is another improvement of this paper.

2) Scheme II: Wavelet + PCA method

a) Image added to noise

In the scheme I (1), the image were added noise, in this paper in different size of Gaussian noise were added are compared, and see the results for detail.

b) Image pre-processing

For face image after adding noise, use (Haar wavelet)[15] two orthogonal wavelet two layers of decomposition respectively, were obtained four sub-map.

c) Fast PCA algorithm to extract facial feature

Fast PCA algorithm for (2) image dimension reduction tonremove the correlation between pixels. Principal components extracted from the training samples, and then complete the conversion by the projection base. In a subsequent experiment to reduce feature vector dimension on after nine sub-graphs to represent the human face samples. Similarly, the use of fast PCA algorithm can also get the main component of the training set face.

d) Classifier

Same to scheme I (3).

3) Scheme III: Wavelet weighted values of + PCA method

On the basis of the second scheme, given a certain weight coefficient after the projection distance. The rest same to the scheme II

4) Scheme IV: MRA- frame + PCA method

The second scheme is carried out to be two layers wavelet decomposition instead of two layers of decomposition of wavelet framework, get nine sub-graph, the rest same to the scheme II.

C. Experimental Results And Analysis

In the experiment, After the test in which 40 individuals five face images, a total of 200 samples were classified, Before adding noise and after adding noise (joined respectively 0.01,0.02,…0.1 etc. different sizes of Gaussian noise) was compared.

Before adding noise, the recognition rate of scheme I is 80% of the traditional PCA method, the recognition rate of scheme II is 77%, the recognition rate was 80.5% of scheme III, the recognition rate of scheme IV is 77%. At this time the gap between the four relatively not large.

But after adding Gaussian noise, we found recognition rate of traditional PCA method will generally increase as the noise recognition rate decreases, and when the noise reaches 0.1 recognition rate below 50%. At the same time when the other three methods of identification rate increased. And the effect of the gap is more bigly compared to the PCA method of added to noise; some have more than 20 percentage points higher. And the recognition rate of scheme III generally higher than scheme II. Further higher recognition rate of some four programs IV. Since the noise distribution Gaussian noise is random, so the noise results in different times would be a slight deviation, and conclusions of this paper are obtained based on each method at least 10 times experiments. Select one of a set of experimental results list in Table 1.

V. CONCLUSION

In this paper, the traditional method of face recognition PCA methods was studied. Found that the traditional PCA method recognition rate will be significantly reduced after added noise in the image, put forward three different improved algorithm for this situation, and on the ORL face database conducted experiments, Experimental results show that the proposed method can improve the recognition effect of adding noise face images. In the next step of the study may change the classification of Study on methods, such as support vector machines (SVM) classification tools, and the influence of the choice of kernel function effectively and SVM kernel function parameters added to noise recognition rate of face images.

TABLE I. EXPERIMENT RESULTS

	Adding noise	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
Recognition rate %	SchemeI	80.0	77.5	76.0	75.5	74.5	70.5	70.0	63.5	58.0	51.5	45.0
	Scheme II	77.0	78.5	80.0	80.5	80.0	79.5	80.0	81.5	80	82.5	81.0
	Scheme III	80.5	81.5	81.0	81.5	84.0	81.0	82.0	83.5	83.0	83.5	84.0
	Scheme IV	86.5	85.0	87.5	87.0	90.0	90.0	88.5	83.5	87.5	90.0	87.5

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