An Exploration of Face Recognition Methods Based on LBP Algorithm and PCA Analysis

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Abstract. Local Binary Pattern is an operator that can be effectively used for facial description, and its application field is relatively wide, which has made great contribution to the research and technical support related to face recognition. The traditional local texture feature extraction method of LBP operator is relatively single and cannot fully synthesize the problem of neighborhood correlation. Therefore, this paper proposes a face recognition method based on the combination of LBP algorithm and PCA principal component analysis method for the above problems. Through the application of this method, it can effectively weaken the influence of noise on the results and show the basic characteristic situation of the sub-block region, and the experiments of this method have confirmed that, compared with the use of PCA, LBP and other methods alone, the method in this study has a significant improvement in the recognition rate.

Keywords: lbp algorithm; pca principal component analysis; face recognition; recognition rate.

1. Introduction

In recent years face recognition technology has become one of the hottest research topics in pattern recognition and graph processing, and this recognition technology has the advantages of non-intrusiveness, simple acquisition equipment, and fast operation, thus it has been widely developed and applied. Using Principal Component Analysis (PCA), Linear Discriminant Approach (LDA), Independent Component Analysis (ICA), and Learning by Patterns (LPP), etc., the global features of the face are extracted, but these methods do not deal well with the local details of the face features and external factors such as illumination and expression, while using Local Binary Patterns (LBP), Histogram of Orientation Gradients (HOG), and Gabor feature extraction, etc., the local binary pattern (LBP), histogram of orientation gradients (HOG), and Gabor feature extraction methods are capable of extracting the texture of the face features, which can be used to recognize the face features[1-2]. The use of local binary pattern (LBP), orientation gradient histogram (HOG), and Gabor feature extraction can provide a good description of the face feature texture and local detail information, and has been widely used. In order to fully extract the feature information of the face and improve the recognition rate, the article uses the improved LBP algorithm, which takes into account the grayscale correlation between the middle pixel and the neighboring pixels as well as the grayscale correlation between the neighboring pixels, and at the same time, the image is divided into regional blocks of the LBP feature extraction to obtain the LBP texture features of the face; at the same time, the combination of the method with PCA significantly reduces the computational scale and improve the operation speed.

2. Image feature extraction based on LBP and PCA

2.1 Basic LBP algorithm

In the basic LBP algorithm, the binary code is used to express the relationship between the grayscale eigenvalue size of the center pixel point and the local neighborhood points, and the corresponding binary codes of all neighborhood points constitute the local structure information of the center pixel point.

As shown in Fig. 1, the basic LBP operator is defined in a 3-pixel × 3-pixel window, and the grayscale value of the center pixel is taken as the threshold value and compared with the grayscale value of the neighboring 8-pixel pixel, and if it is larger than the grayscale value of the center pixel, it is marked as 1, otherwise it is marked as 0[3-4]. By connecting these markers clockwise starting from the upper left corner, an 8-bit unsigned binary number is obtained, the corresponding decimal number of this binary number is the LBP value of the center pixel point, and the LBP value of the center pixel point is expressed in binary code. The LBP value of the pixel point is expressed by the formula

$$LBP(x_i, y_i) = \sum_{p=1}^{p} s(x)2^{p-1} s(x) = \begin{cases} 1, g_p - g_i \geq 0 \\ 0, g_p - g_i \langle 0 \end{cases} \quad (1)$$

where: p is the neighboring pixel point; g_p is the pixel value of the neighboring point; g_i is the pixel value of the center point; $s(x)$ is the binary function. The LBP image of the original image is obtained by transforming the whole image using Eq. (1), and the LBP histogram of the whole image is obtained statistically, thus obtaining a 256-dimensional histogram as the texture features of the image.

LBP image feature extraction is closely related to the position of the pixels, therefore, direct LBP image feature extraction on two images may affect the recognition rate because the two images are not aligned[5-6]. Therefore, the regional chunking LBP image feature extraction is used, that is, the face image is divided into several sub-regions, and then the LBP histogram is obtained separately for each sub-region image, the sub-regions are counted, and the LBP histogram of the whole image is established, and then face recognition is performed.

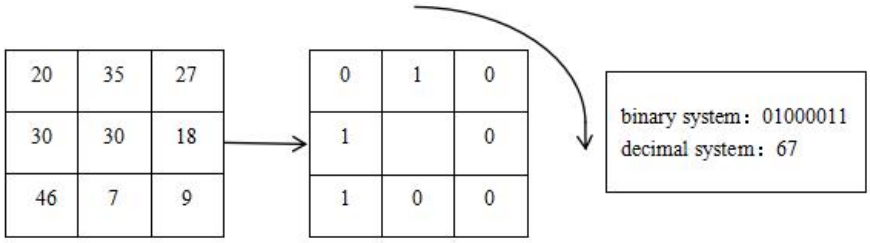


Fig. 1 Basic LBP operator

2.2 Improved LBP algorithm

The traditional LBP algorithm directly calculates the center pixel value as the threshold value, which only considers the influence of the center pixel, and it is easy to obliterate the details when the center pixel value is too large or too small. Therefore, this paper proposes an improved LBP algorithm that considers the effects of both the center pixel value and the neighbor pixel value. Specifically, the method calculates the neighborhood

If C is within the limit, the center pixel value is selected as the threshold value and the LBP value is calculated, which fully considers the role of the center pixel value and the neighboring pixel value, and effectively removes the influence of the center pixel value that is too large or too small on the image feature extraction and more accurately describes the local image features; otherwise, the median value of the neighboring pixel and the center pixel is selected as the threshold value, and a comparison is made to reduce the influence of the noise points. comparison is made to reduce the influence of noise points[7-8]. The specific process is as follows.

(1) Construct a 3-pixel × 3-pixel window and calculate the sum of squares C of the difference between the neighboring pixel value and the center pixel value in the window, denoted by

$$C=\sum_{P=1}^{8}\left(g_p-g_{i,j}\right)^2 \qquad (2)$$

Where: g_p is the neighborhood pixel value; g_i, j is the center pixel value.

(2)Set the limit value of C as W, judge the size of C and W. If C ≤ W, select the center pixel value as the threshold value and calculate the LBP value, i.e., use Equation (1) to calculate the LBP value; when C > W, select the median of the 9 pixel values as the threshold value and calculate the LBP value, expressed as

$$LBP(x_i,y_i)=\sum_{p=1}^{p}s(x)2^{p-1}s(x)=\begin{cases}1, g_p-g_M\geq 0\\ 0, g_p-g_M\langle 0\end{cases} \qquad (3)$$

where: p is the neighboring pixel point; g_p is the neighboring point pixel value; g_M is the median of 9 pixel values; $s(x)$is the binary function, LBP is better robust to local area illumination, and after many experiments, the recognition rate is higher when W is 200.

(3) Calculate the LBP value in step (2) to get the LBP feature image.

(4) Count the number of times the LBP value appears, and get the LBP histogram.

2.3 PCA Principal Component Analysis

PCA (Principal Component Analysis) method is a dimensionality reduction method with minimal loss of global features. The feature space transformation using the rotated coordinate system is the essence of the PCA algorithm, and this transformation can greatly retain the original data information, while reducing the dimensionality of the original space, which reduces the data redundancy and also reduces the amount of computation[9]. The new orthogonal features obtained after mapping are called principal components, and these orthogonal features minimize the loss of data while reducing the dimensionality, which is conducive to reducing the computational overhead of the algorithmic procedure.

The specific operation procedure of the PCA algorithm:

(a)Assume that a sample data matrix of n after homogenization is input;

(b)Calculate the covariance matrix of the sample matrix:

$$C=\frac{1}{mn}X\times X^T \qquad (4)$$

Where: matrix C is a real symmetric matrix;

(c)Solve for the eigenvalues λ_i and corresponding eigenvectors ξ_i and satisfy the relation

$$C\xi_i=\lambda_i\xi_i(1,2,...,n) \qquad (5)$$

(d) Construct the matrix P consisting of the eigenvectors corresponding to the first K principal components;

$$p=\begin{bmatrix}\xi_1 & & & 0\\ & \xi_2 & & \\ & & \ddots & \\ 0 & & & \xi_k\end{bmatrix} \qquad (6)$$

(e) Calculate the matrix Y after dimensionality reduction projection, which is the data matrix after PCA processing:

$$\mathrm{Y}=\mathrm{PX} \qquad Y=PX \qquad (7)$$

3. Experimental results and analysis

3.1 Experiments on the Improved LBP Algorithm

Comparative verification of the LBP algorithm before and after the improvement is performed using the Yale face database.The Yale face database has 15 people with 11 images each, and the image size is 100 × 100 pixels[10].The experiments change the number of each person in the training samples (from 3 to 10), and the rest are used as the test samples to compare the recognition of the LBP algorithm before and after the improvement, which is shown in Fig. 2

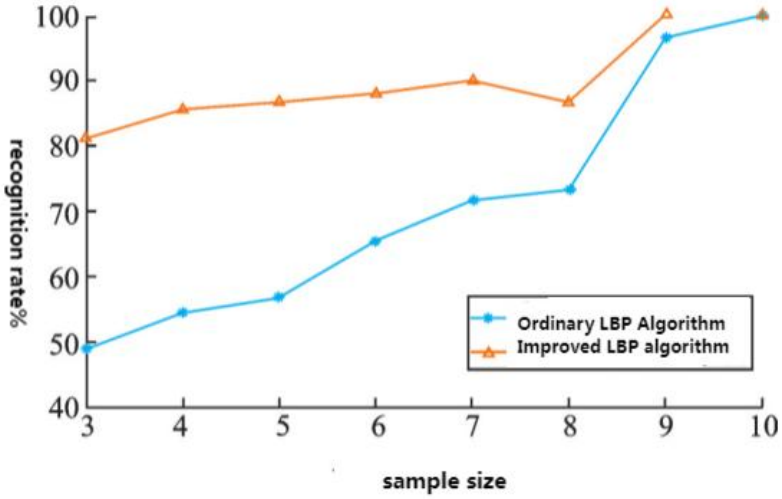
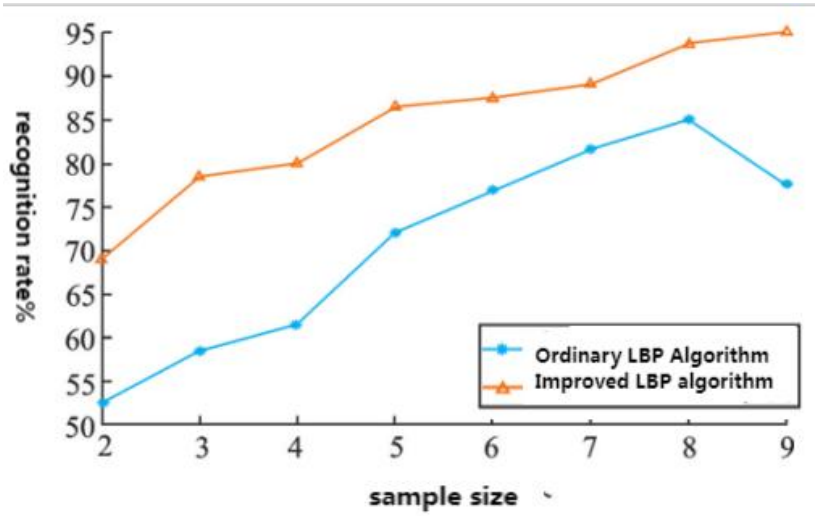


Fig. 2 Recognition rate of LBP algorithm before and after improvement of Yale face library

The LBP algorithm before and after improvement is compared and verified using the ORL face library, there are 40 people in the ORL face library, 10 images per person, and there are different degrees of changes in the facial expressions and facial details of the people[11]. The experiment



changes the number of training samples each sample (from 2 to 9), and the rest are used as test samples to compare the recognition of LBP algorithm before and after the improvement, and the experimental results are shown in Fig.3. From the experimental results Fig. 2 and Fig. 3, it can be seen that the LBP face recognition application gradually improves the recognition rate with the increase in the number of training samples, and the improved LBP has obviously improved in the recognition rate.

Fig. 3 Recognition rate of LBP algorithm before and after improvement of ORL face library

4. Face Recognition Performance Test

The performance test of Face Recognition Attendance APP is mainly to test the efficiency and accuracy of face recognition in the industrial open-air environment, so as to achieve fast attendance and accurate attendance[12]. Taking 70 males and 30 females as test samples, among which 50 males and 10 females wear glasses, 30 males and 20 females wear masks, several rounds of tests were conducted under different conditions, and the results of the face recognition attendance test are shown in Table 1:

Table 1 Face recognition performance test

Testing environment	Number of testers	Fastest Recognition Time (s)	Slowest Recognition Time (s)	Average recognition time (s)	Correct recognition rate
Well lit, dusty	100	1.20	2.04	1.56	96%
Low light, dusty	100	1.55	2.45	2.01	94%
Plenty of light, wear glasses	60	1.22	2.26	1.62	96%
Well-lit, wearing mask	50	2.18	3.26	2.55	32%

Considering the poor environment of industrial open-air operations, there may be a large amount of dust covering the face, in the case of good light with dust on the face, the accuracy of face recognition reaches 96%, and the average recognition time is within 2 s. In the case of weak light, it will slightly affect the efficiency and correctness of the system's recognition, but it still meets the requirements of the Attendance APP[13]. From the analysis of the experimental data, it can be seen that whether the face wears glasses has almost no effect on the results and efficiency of attendance, but wearing a mask greatly reduces the correct recognition rate of face recognition.

After the above test and comparative analysis, the face recognition method based on LBP in the attendance APP in this paper can effectively improve the efficiency of enterprise attendance management, and has certain practical value.

5. Conclusion

In this paper, based on the traditional LBP algorithm, an improved LP algorithm combined with PCA algorithm is proposed as a face recognition method, which extracts local texture features from the face chunks, and combines the histogram of the face in each chunk to form a feature vector matrix. Then the matrix is dimensionalized by PCA, so as to obtain the main feature information. By applying the algorithm of this paper to the experimental analysis of the face recognition performance of the time and attendance system, the results can be seen that the face recognition accuracy of the method proposed in this paper is as high as 96%, and the average recognition time is within 2 seconds, which reduces the recognition time and improves the recognition efficiency, and therefore has a certain practical value.

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