A Real-time Face Recognition System Based on the Improved LBPH Algorithm

XueMei Zhao, ChengBing Wei*
School of Electronic Information
Qingdao University
Qingdao, China
e-mail: 2932472518@qq.com; wei_20002000@126.com

***Abstract*—The Local Binary Pattern Histogram(LBPH) algorithm is a simple solution on face recognition problem, which can recognize both front face and side face. However, the recognition rate of LBPH algorithm under the conditions of illumination diversification, expression variation and attitude deflection is decreased. To solve this problem, a modified LBPH algorithm based on pixel neighborhood gray median(MLBPH) is proposed. The gray value of the pixel is replaced by the median value of its neighborhood sampling value, and then the feature value is extracted by the sub blocks and the statistical histogram is established to form the MLBPH feature dictionary, which is used to recognize the human face identity compared with test image. Experiments are carried on FERET standard face database and the creation of new face database, and the results show that MLBPH algorithm is superior to LBPH algorithm in recognition rate.**

Keyword-face recognition; local binary pattern histogram; neighborhood median; statistical histogram; face database

I. INTRODUCTION

Face recognition technology is an important research project in the field of computer vision and pattern recognition, it can identify the identities and other information according to the visual features of face image, having a very broad prospects for development. It is widely used in authentication, criminal investigation, video surveillance, robot intelligence and medical science and so on. It has wide application value and commercial value. As a biological feature, facial features have the characteristics of good, direct and convenient compared with other biological features. Therefore, face recognition is more acceptable for users.

Over the years, many scholars have developed a variety of kinds of face recognition algorithms, including Sparse Coding(SC) algorithm[1], Local Binary Pattern (LBP) algorithm[2], Histograms of Oriented Gradients(HOG) algorithm[3], Deep Convolution Network algorithm[4], Linear Discriminant Analysis (LDA) algorithm[5], Gabor feature algorithm[6], but also in the unceasing development. OpenCV is an open source computer vision library that has three built-in face recognition algorithms, Eigenfaces[7], Fisherfaces[8] and Local Binary Pattern Histogram (LBPH)[9]. Compared with the other two algorithms, the LBPH algorithm can not only recognize the front face, but also recognize the side face, which is more flexible. In order to enhance the robustness of illumination changes, expression change and attitude deflection, a LBPH algorithm based on pixel neighborhood gray median(MLBPH) is proposed. The gray value of the pixel is replaced by the median value of its neighborhood sampling value，and then creating the face database of our own, extracting LBP feature and MLBP feature, and being trained in the face database. After that, it is extracted the feature of testing images, established block histogram, and compared with the database, and then printed the corresponding name in face recognition frame.

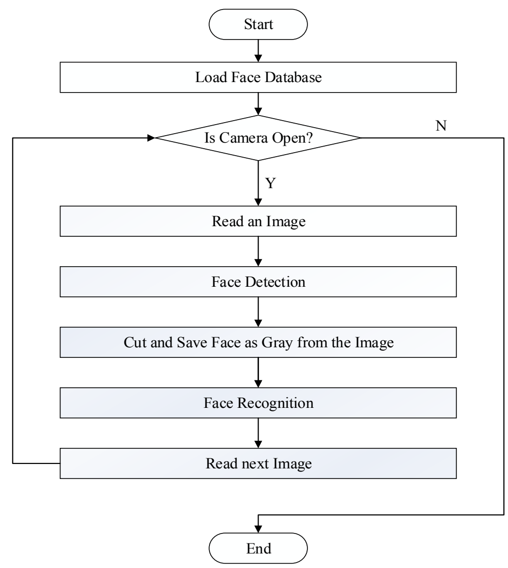

Figure 1. System flow chart.

II. OVERALL DESIGN

Face recognition system includes four main parts: information acquisition module, feature extraction module, classification module and training classifier database module. The image information collected by the information acquisition module will be used as a test sample for analysis. In the feature extraction module, a series of salient features which can represent human identity information are extracted and analyzed. In the classification module, the classifier trained by database is used to classify the test samples to determine the identity information of the samples. The system flow chart is shown in Fig. 1.

A. Face Detection

OpenCV provides a Haar cascade classifier, which can be used for face detection. The Haar cascade classifier uses the AdaBoost algorithm to detect multiple facial organs including the eye, nose, and mouth. First, it reads the image to be detected and converts it into gray image, then loads

Haar cascade classifier to judge whether it contains human face. If so, it continues to examine the eyes, nose, and mouth and draw a rectangular frame on the corresponding organ. If not, it continues to test the next picture. The flow chart of the detection process is shown in Fig. 2.

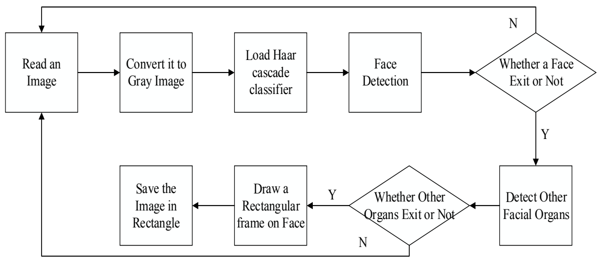

Figure 2. Face detection flow chart.

B. Feature Extraction

The LBP operator is used to describe the contrast information of a pixel to its neighborhood pixels. The original LBP operator is defined in the window of 3*3. Using the center pixel value as the threshold of window, it compares with the gray value of the adjacent 8 pixels. If the neighborhood pixel value is greater than or equal to the center pixel value, the value of pixel position is marked as 1, otherwise marked as 0. The function is defined as shown in formula 1.It can be described in Fig.3.

$$s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases} \tag{1}$$

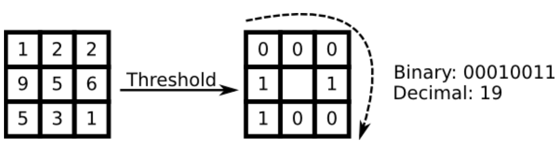

Figure 3. Original LBP operator.

In this way, the 8 points in the 3*3 neighborhood are compared to produce 8-bit binary numbers. Converting it to decimal numbers, the LBP values of the central pixel points of the window are obtained, which is used to reflect the texture features of the region. The current LBPH algorithm uses an improved circular LBP operator. It can be represented by Fig.4. and formula 2.

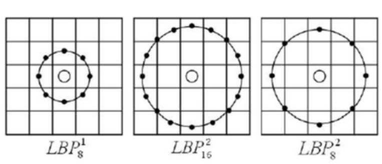

Figure 4. Circular LBP operator.

$$LBP_P^R = \sum_{P=0}^{P-1} s(g_P - g_C)2^P \tag{2}$$

g_p is the gray value of P neighborhoods of the pixel C, the radius of which is R. g_c is the gray value of the pixel $C(x_c,y_c)$.

This algorithm makes the LBP operator no longer limited to fixed radius and neighborhood, and can meet the needs of more different size and texture features.

For each pixel of an image, it computes its LBP eigenvalues. Then these eigenvalues can form a LBP feature spectrum. The LBPH algorithm uses the histogram of LBP characteristic spectrum as the feature vector for classification. It divides a picture into several sub regions, then extracts LBP feature from each pixel of sub region, establishing a statistical histogram of LBP characteristic spectrum in each sub region, so that each sub region can using a statistical histogram to describe the whole picture by a number of statistical histogram components. The advantage is to reduce the error that the image is not fully aligned in a certain range.

In order to enhance the robustness of illumination changes, expression change and attitude deflection, inspired by median filtering, a LBPH algorithm based on pixel neighborhood gray median(MLBPH) is proposed. Compared with the LBPH algorithm, the improvement of the MLBPH algorithm is that when the LBP eigenvalues are calculated, the central pixels are replaced by the median values of the sampled values of their neighborhood sampling points. The definition of the median is shown in formula 3. The MLBP eigenvalue can be described in Fig. 5.

$$\begin{cases} x_{(1+n)/2} & \text{, n is odd number} \\ \left(x_{n/2} + x_{n/2+1}\right)/2 & \text{, n is even number} \end{cases} \tag{3}$$

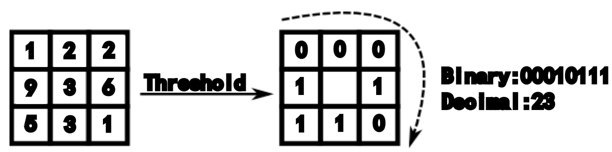

Figure 5. MLBP operator.

The rest steps and parameters of the MLBPH algorithm are the same as those of the LBPH algorithm. The flow chart of the MLBPH algorithm is shown in Fig. 6.

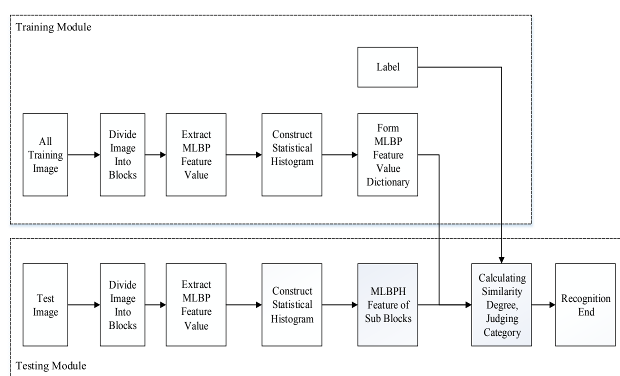

Figure 6. MLBPH algorithm flow chart.

C. Face Database

Experiments were performed on the FERET face database and the created face database.

The FERET database contains multiple subsets .Select one of the subsets for the experiment. The subset contains 200 different people, each with 7 different face images, including light, facial expressions, and gesture changes. Some of the human face images are shown in Fig. 7.

Figure 7. Some images of FERET face database.

Created face database stores our own face images. It is created on the basis of face detection. Make different facial expressions and postures to scene and detect faces. The saved pictures are stored in a same folder to form the created face database. Some of the human face images are shown in Fig. 8.

Figure 8. Some images of created face database.

TABLE I. DIFFERENT RECOGNITION RATE OF FERET DATABASE

Algorithm	Correct Times	Wrong Times	Recognition rate
LBPH	1122	78	93.50%
MLBPH	1167	33	97.25%

III. EXPERIMENTS AND DISCUSS

In the experiment, each person in the face database has different labels. First, train the face database, then extract the LBP texture features and MLBP texture features of each test image. Finally, classify and recognize the face information.

A. Illumination Change Experiment

Select the weak illumination images of each person as test-images, the other images are used as the train-images, so there are 1200 images in training-library. Repeat the experiment 10 times, then take the average. The results are shown in Table I.

Read images in the dim light, read 500 frames at a time, repeat 10 times, and take the average. The results are shown in Table II. The recognition results are shown in figure 9.

TABLE II. DIFFERENT RECOGNITION RATE OF CREATED DATABASE

Algorithm	Correct Times	Wrong Times	Recognition rate
LBPH	146	354	29.2%
MLBPH	187	313	37.4%

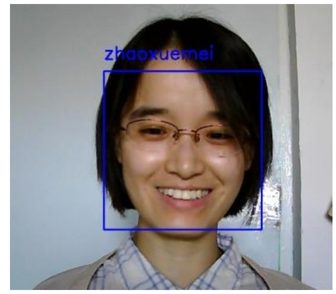

Figure 9. Face recognition in dim light.

As can be seen from TABLE I and TABLE II, the MLBPH algorithm can more effectively highlight the local features of illumination changes, thus improving the recognition rate.

B. Expression Change Experiment

Select the different expression images of each person as test-images, the other images are used as the train-images, so there are 1200 images in training-library. Repeat the experiment 10 times, then take the average. The results are shown in TABLE III.

TABLE III. DIFFERENT RECOGNITION RATE OF FERET DATABASE

Algorithm	Correct Times	Wrong Times	Recognition rate
LBPH	1176	24	98.00%
MLBPH	1186	14	98.83%

Read images with different expression, read 500 frames at a time, repeat 10 times, and take the average. The results are shown in TABLE IV. The recognition results are shown in figure 10.

TABLE IV. DIFFERENT RECOGNITION RATE OF CREATED DATABASE

Algorithm	Correct Times	Wrong Times	Recognition rate
LBPH	422	78	84.4%
MLBPH	441	59	88.2%

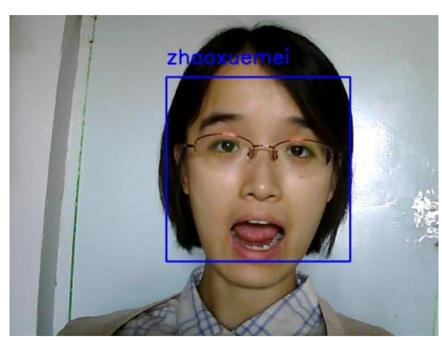

Figure 10. Face recognition of different expression.

As can be seen from TABLE III and TABLE IV, the MLBPH algorithm can more effectively highlight the local features of expression changes, thus improving the recognition rate.

C. *Attitude Deflection Experiment*

Select the different attitude images of each person as test-images, the other images are used as the train-images, so there are 1000 images in training-library. Repeat the experiment 10 times, then take the average. The results are shown in Table IV.

TABLE V. DIFFERENT RECOGNITION RATE OF FERET DATABASE

Algorithm	Correct Times	Wrong Times	Recognition rate
LBPH	886	114	88.60%
MLBPH	926	74	92.60%

In the experiment, rotating the head around the camera, it can be found that the deflection angle is about 30 degrees at both left and right. Read 500 frames at a time, repeat 10 times, and take the average. The results are shown in Table VI. The recognition results are shown in figure 11.

TABLE VI. DIFFERENT RECOGNITION RATE OF CREATED DATABASE

Algorithm	Left 30°	Front	Right 30°
LBPH	50.2%	76.2%	43.4%
MLBPH	55.0%	82.6%	48.6%

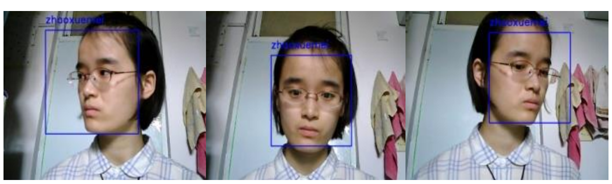

Figure 11. Face recognition of different attitude.

As can be seen from TABLE V and TABLE VI, The front face recognition rate is higher than the side recognition rate. Meanwhile, the recognition rate of MLBPH algorithm is higher than that of LBPH algorithm under the same angle.

D. *Experiment of Face Proportion Change of Lens*

When the distance between the faces with camera is different, the face proportion of lens is also different, which results in different recognition rates. Experiments were conducted with 3 proportions, as shown in Fig.12. Fig.13. Fig. 14. Each proportion reads 500 frames and repeat 10 times, calculates the average of the 10 identification rates, and results are shown in Table VII.

TABLE VII. DIFFERENT RECOGNITION RATE OF CREATED Database

Algorithm	10%	30%	60%
LBPH	97.4%	76.2%	29.4%
MLBPH	99.2%	82.6%	36.2%

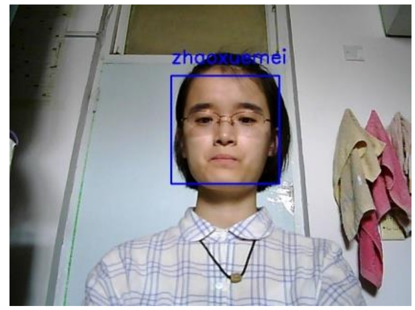

Figure 12. 10% recognition rate of created database.

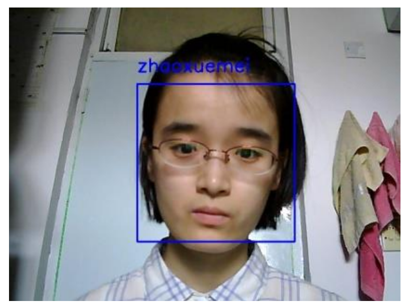

Figure 13. 30% recognition rate of created database.

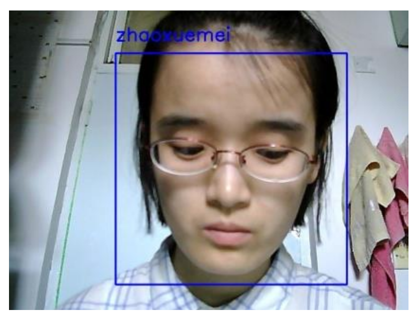

Figure 14. 60% recognition rate of created database.

As can be seen from TABLE VII, the smaller the proportion of the face lens, the higher the recognition rate. That is, in the distance without affecting recognition, the farther away from the lens, the higher the face recognition rate is. This is because the camera has some nonlinear distortion. The nearer the face distance lens is, the more serious the distortion is, which leads to the decrease of recognition rate. However, in the same distance, the recognition rate of MLBPH algorithm is higher than that of LBPH algorithm. The feasibility of the improved algorithm is proved once again.

IV. CONCLUSION AND PROSPECT

The recognition rate of local binary pattern histogram (LBPH) algorithm can be reduced under illumination, expression change and attitude deflection. To solve this problem, a LBPH algorithm based on neighborhood gray median(MLBPH) is proposed. Use the median of the neighborhood sampling values to instead of intermediate values, thereby reducing the effects of extraction conditions on the characteristic value of illumination. Experiments are carried out on FERET standard face database and created face database. And the results show that MLBPH algorithm is superior to LBPH algorithm in recognition rate. However, the problem of lens distortion still has not been solved, which will affect the face recognition rate. This is the direction of our next work.

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