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Oriented Changing Light Facial Image Recognition Based on Sub Pattern Texture Analysis

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Abstract

Face recognition (FR) system can automatically identify or check face image from a digital camera or image generation equipment, in order to do this, to extract facial features from images obtained, and compared with face data in the database. At present, almost all of the FR face barriers associated with facial Angle, including the lack of light and the low resolution, these problems has greatly reduce the recognition rate. In order to solve this problem, this paper proposes a face recognition framework based on the sub pattern under the condition of illumination change, first of all, the framework using minimize the total variation image of discrete cosine transform (DTV) and the Gabor filter, and combined the sub-mode analysis (SMP) and distinguish the accumulative feature transformation (DAFT), can effectively solve the face recognition problem of light conditions big change, secondly by extracting the texture characteristics of local model is not sensitive to illumination changes, using Distance transformation measures (Distance Conversion Metrics, DCM) and k-means (K-Mean) algorithm, the recognition rate of face recognition is improved effectively. The effectiveness of the method verified respectively on the two face library: ATR - Jaffe and Yale, the experimental results show that compared with other state-of-the-art methods, the proposed method in dealing with the face recognition problem under the condition of the unrestricting obtained better recognition effect.

Keywords: *Sub Pattern Analysis, Face Recognition, Feature Extraction, Local Mode, Texture Descriptor, Distance Measurement*

1. Introduction

In video surveillance, face recognition [1] authentication and information security are becoming more and more widely in the areas of application, but factors such as illumination, posture, facial expression and occlusion will affect its robustness. In the past few decades, facial recognition technology got great development, feature extraction is the key step in the face recognition, and its main purpose is to dimension reduction. Image representation in the field of computer vision and image processing is one of the key factors. Usually adopted method is to convert the original image into a new form; the identification process to illumination changes, rotation, scaling, posture, shade, etc. has little influence. Through image representation, this paper puts forward some techniques to solve the problem of face recognition. From the point of all methods, PCA [1] and LDA [2] are probably the most outstanding method in face recognition. Feature face algorithm is the best reconstruction method based on minimum mean square error; it converts the image in order to make all of the face image dispersion value maximization. This shows feature face algorithm on the distinguish ability is not the best method [3-4]; it depends on the difference between different levels rather than stretching between all levels.

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Literature [5-6] proposed joint Gabor filter and LBP, it's called local ng BaiErYuan schema order histogram (LGBPHS), it will be a Gabor filter is applied to the image of the face of the five dimensions and eight directions, with LBP in all 40 then produces LGBPHS luminosity. Literature [7] proposed expanding LGBPHS, Gabor phase used to encode and represent Gabor phase histogram (HGPP). Literature [8], expand the quadrant first from the face image based on Gabor phase information extraction, coding phase change with global and local GPPS, when LGPP uses local changes XOR pattern on the coding, GGPP [9] capture produce change by the given ogre BaiXiaoBo direction change. The most traditional unsupervised algorithm [10] (PCA) mainly analyzes [11-13]. Friedman proposed regularized discriminate analysis (Regularized LDA, RLDA) [14], its core idea is to give classes divergence within the matrix to increase a small perturbation, so as to avoid such divergence within the singularity of the matrix, this method directly on the original high-dimensional image processing, and large amount of calculation. Jin *et al.* [15] proposed uncorrelated discriminate analysis (Uncorrelated LDA, ULDA), ULDA's important feature of extraction is statistical uncorrelated. Literature [16] using the generalized singular value decomposition method solve the problem of small sample, puts forward the generalized discriminate Analysis (Generalizing Discriminate Analysis, GDA). Literature [17-18] propose zero space Linear discriminate Analysis (Null - space Linear Discriminate Analysis, NLDA) method and confirmed the kind of divergence within the matrix of zero space contains important identification information, compared with other Linear methods can obtain better result.

In large sample cases, however, such divergence matrix may not be zero space, thus unable to use NLDA method. To find the nonlinear structure of data, [19] introduce nuclear technology, nuclear identification method was proposed based on Fisher criterion (Kernel Fisher Discriminate Analysis, KFD), literature [20]has carried on the similar research, they are essentially the same, to avoid confusion, this article unified called Kernel discriminate Analysis (Kernel Discriminate Analysis such sis, KDA). CAI *et al.* [21] unified the traditional LDA method to the graph embedding framework (graph embedding) proposed the Spectral Regression Discriminate Analysis (Spectral Regression Discriminate Analysis, referred to as the SRDA), SRDA has great computational advantage compared with the traditional Discriminate Analysis method. Considering the SRDA is still a linear dimension reduction algorithm, literature [22] introduced the nuclear technology, the SRDA algorithm is extended to nonlinear dimension reduction field Spectral Regression Kernel Discriminate Analysis (Spectral Regression Kernel Discriminate such Analysis, SRKDA) [23-24].

This article innovation point mainly has the following two aspects:

(a) in order to solve the problem of lower recognition rate under the condition of unrestricted, this paper proposes a face recognition method based on local pattern texture descriptor, by extracting the texture characteristics of local model is not sensitive to illumination changes, using Distance transformation measures (Distance Conversion Metrics, DCM) and k-means (K - scheme) algorithm, the recognition rate of face recognition is improved effectively. The effectiveness of the proposed method respectively in two general ATR - Jaffe and Yale face on the library. Proposed method consists of preprocessing, feature extraction and classification recognition stage, among them, as shown in figure 1 as the image preprocessing steps.

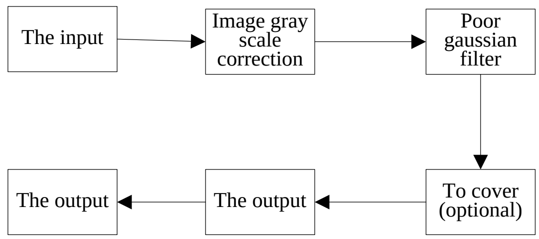

Figure 1. The Image Preprocessing Steps

(b) Image grayscale used the lack of light correction of the initial stage. But it does not remove all the influence of the intensity gradient, such as the cover effect of the variance of Gaussian filtering, this contains a blurred version of the original gray image, and another is not subtraction between fuzzy versions. The method strengthens the high resolution image. Cover stage, will hide away unrelated area in the image. The density equilibrium phase contrast, adjust the image. This step is for later processing stages, standardization of density value.

2. Proposed Methods

2.1. Local Binary Pattern (LBP)

LBP operation [5] is the best texture descriptor, it is widely used in different applications. Proven it is high to distinguish, it's key strengths include for drab gray level change remains unchanged, and computational efficiency, so to make it more suitable for the demand of the image analysis tasks. Philosophy of using local binary pattern to face description is the human face can be seen as better by these operations described model based on the theory of the combination, LBP was originally designed for texture description work operation, threshold of each pixel of the adjacent point through the center pixel setting and will be the results into a binary number, the operation will tag assigned to each pixel of an image. Then these tags histogram can be used as a texture descriptor, light change based on local binary pattern operators . Formally, LBP operator can be expressed as:

$$LBP\left(Xc,Yc\right)=\sum_{n=0}^{7}2^{n}S\left(in-ic\right) \tag{1}$$

Among them, n represents eight adjacent points of the center pixel, when ic and in represent grey value of c and n ,when $u \geq 0$, $s(u)=1$,and otherwise $s(u)=0$.

Represents [5] described two original expansion of the operator. The first adjacent point definitions for different size of local binary pattern, this makes working with different size of grain is feasible. The second defines the so-called consistent patterns: if a binary pattern includes up to two from 0 to 1 according to a conversion, according to a local binary pattern is consistent, or when the model is a cycle, and vice versa. For example, model 00000000 (0), 00000000 (2) and 11001111 (2) is consistent, but the model 11001001 (4) and 01010011 (6) is not consistent. In LBP histogram computation, using a consistent pattern is because histogram for each consistent patterns have a single binary representation, all of the mode of non-uniform distribution into a single binary. Consistency is very important, because it could contain the main patch characteristics of structural information (such as edge and Angle). Represents [7] only 58 in 256 8-bit mode is consistent, nearly 90% represents adjacent points is consistent, a lot of the rest model contains essential noise. Therefore, when the LBP histogram is changed, all not consistent model is assigned to a single point, can significantly reduce the number of binary, without losing too much information at the same time.

Making face image into multiple local area, texture descriptor separate extracted from each region, connect these descriptors of the global descriptor of a face. Figure 2 shows the face image into multiple rectangular area as an example.

Figure 2. A Picture Divides the Face Image into $7\times 7, 5\times 5, 3\times 3$ **Rectangular Area**

The basic histogram can be extended a person to face region's space coding space enhanced histogram of space connection code. When m people face block areas $R_0, R_1 \cdots R_{m-1}$ have been identified, a histogram is calculated separately for each zone. Joint each histogram results can produce space enhanced histogram. The size of the histogram is $m\times n$, where n is the length of single LBP histogram. Reinforced the histogram in the space, can use three different local levels face to describe:

Histogram LBP logo contains an information of gray model, the logo in a small area on the sum to create a regional level of information, connect the area histogram produced a face of the global description. It is important to note when using this method based on histogram, don't like figure 4, $R_0, R_1 \cdots R_{m-1}$ these areas are not necessarily the rectangle. They need not be the same size or shape; also do not need to cover the whole image. For example, they can be located like EBGM method datum in the circular area, with partial overlap is also possible.

2.2. Local Ternary Patterns (LTP)

LBP is highly distinguishable features in texture classification, they can resist lighting effects to some extent, but also for drab gray level transformation is a constant. But because they just close to the center pixel values, they will be sensitive to noise, mainly in area that close to a consistent image, at the same time, it is sensitive to light intensity gradient. Many face region relatively consistent, in the area investigated whether these features robustness can be improved is legal. This section extended binary for ternary encoded, namely local ternary patterns, it will make grey value quantification for 0 around an area of ic, the quantitative above for + 1, the quantification below for 1, for example, using three value function instead of indicators $S(u)$:

$$S^{'}(u,ic,t)=\begin{cases}1 & u\geq ic+t\\ 0 & u-ic+t\\ -1 & u\leq ic+t\end{cases} \tag{2}$$

Using ternary LTP [7] code instead of a binary LBP code. t is a specific user threshold. This LTP coding has resistance to the noise, but no longer kept strict invariance to greyscale. In figure 3 shows the LTP coding steps, setting threshold to five here, that is redundant interval [49, 59].

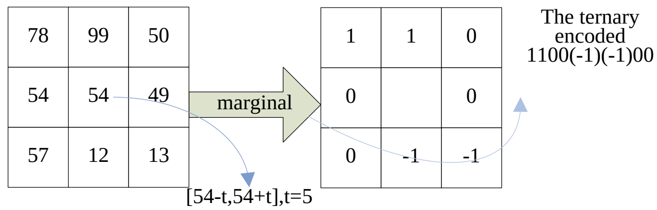

Figure 3. Shows Basic Local Ternary Patterns Operation

When LTP is used to conduct virtual matching, can use the estimate code, but consistent logical argumentation is also used in the ternary instances. Simplicity, the experiment adopted divides each three yuan into positive and negative two equal parts (as shown in figure 4), then these as separate histogram and local binary pattern of similarity measure computation descriptors of two separate channels, only at the end of the calculation results will be all together.

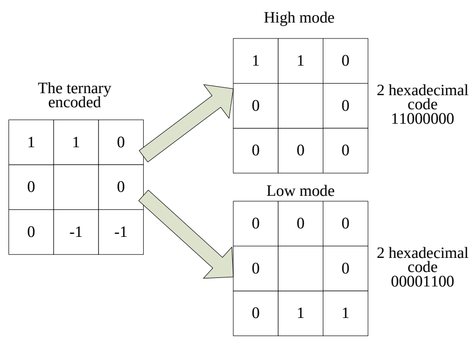

Figure 4. Ternary Code is Divided into Positive and Negative LBP Code

2.3. Similarity Measure Distance Transformation

Using similarity measure is a local binary pattern based methods in face recognition [2], it divided face image is into the grid of regular cell and the local binary pattern of cell, finally using the recent adjacent classification in the face recognition:

$$X^2(p,q)=\sum_i \frac{(pi-qi)^2}{(pi-qi)} \tag{3}$$

Among them, p,q are respectively descriptor (vector) histogram of image region.

Divided face image into a regular grid seems to be some arbitrary: cell is not aligned according to the needs and facial features, partition is likely to cause aliasing caused by abrupt space quantization (descriptor contributions) and spatial resolution loss (because the position of each grid cell no coding). Due to misalignment, the propose all of the code value given is to provide light and space for small deviation from the group of strong virtual consistent some leeway, using class hausdorff distance similarity measure seems to be appropriate, namely uses each LBP or LTP pixels in the image coding, and testing whether the same code appears in the image of similar position, weighted smoothing down with image distance. Such a scheme should be able to realize matching based on appearance image and easy control space relaxation degree, the distance transformation can be used to implement this plan.

For *a* 2 *d* reference images, you can find the binary or ternary encoded image, and then transformed into a sparse binary image sets, corresponding to every possible binary or ternary encoded values (such as consistent coding image of 59). Each code specify its special binary or ternary encoded values of pixels in position, and then calculate its distance transform image. Each pixel with encoding is given the recent images of the distance (the following experiment is two-dimensional Euclidean distance). The distance between the image and the similarity measure can be expressed as:

$$D(X,Y)=\sum_{pixels(i,j)\ of\ Y} w\left(d_X^{Ky}(i,j)(i,j)\right) \quad (4)$$

It is the code of image pixel value, is also a custom function, it pass losses to the recent match encoding of a pixel point on the given space distance. This study tested the gaussian similarity measure and cut a linear distance, they are of a similar performance section distance, gives a good performance. For 120×120 images, including the iris is the radius of the six pixels or nostrils, all global face alignment, within some pixels to the default parameter value is pixels.

2.4. The Sub- model Analysis

$$G_\sigma(\vec{\xi},\vec{x})=\frac{1}{\sigma\sqrt{2\pi}}\exp\left[-\|\vec{\xi}-\vec{x}\|/2\sigma^2\right]$$

σ is the standard deviation of the joint probability distribution. Formally, $DooG$ function of different directions θ can be expressed as:

A 2-d anisotropic gaussian function is defined as:

$$DooG_{\sigma,d,\theta}(\vec{\xi},\vec{x})=G_\sigma(\vec{\xi'},\vec{x'})-G_\sigma((\xi_1',\xi_2'+d),\vec{x'}) \quad (5)$$

Among them, $\xi_1'=\xi_1\cos\theta+\xi_2\sin\theta$, is the similar with $\vec{x}'$ defined, $\xi_2'=-\xi_1\sin\theta+\xi_2\cos\theta$. It is important to note that the $DooG$ and first derivative of Gaussian function (GD) are very similar; they measure different local variables between the positive and negative area. GD used for measuring the local change, such as the boundary change. The level is the highest when DG at the border. However, the distance between the positive and negative region can be adjust by changing the parameter d. $DooG$ is useful; therefore, it can be used to measure the differences of difference points, such as the difference between two objects or texture. So, GD is likely to be the right tools, such as in boundary detection, a more useful $DooG$ can be used to measure the difference between textures. Three parameters (σ,d,θ) is to describe texture. $DooG$ coding function can be defined as:

$$\varphi_{\sigma,d,\theta}(\vec{x})=\int\int Y(\vec{x})DooG_{\sigma,d,\theta}(\vec{\xi},\vec{x})d\vec{\xi} \quad (6)$$

Measuring texture changes of φ function with in the center positive gauss and give the difference between the positive and negative values, therefore, we define functions are as follows:

$$k(v)=\begin{cases}1, z\ge 0;\\0, z<0;\end{cases} \quad (7)$$

ς represents 0 or 1, therefore, each pixel can be expressed as:

$$C(\vec{x})=\{c_1,c_2,\cdots c_n\} \quad (8)$$

$$c_i=\zeta(\varphi_{\sigma,d,\theta_i}(\vec{x})) \quad (9)$$

θ_i is $DooG$ specific direction, such as $\theta_i=0^\circ,15^\circ,\cdots345^\circ$, $\theta=15, n=\frac{360}{\theta}$. A pixel in an image can be encoded as micro patterns, such as in literature [6] Dugan's Iris Code and

LBP in literature [9]. In this proposed based on micro rotation invariant pattern analysis coding method, from c_1 to c_n (n is texture coding number) start coding. Time micro pattern encoding operation can be represented as:

$$Y=\sum_{i=1}^{n}[(\alpha c_i-(c_i\cdot c_{i-1}\cdot c_{i+1}))+|c_i-c_{i+1}|\cdot\omega_1]+ \\ |c_i-(c_{i+\frac{n}{2}-1}\cdot c_{i+\frac{n}{2}+1})|\cdot\omega_2+\sum_{i=2}^{n/2}|c_i-c_{i+\frac{n}{2}}|\cdot\omega_3 \tag{10}$$

α, w_i The only one constant according to every user, successive $|c_i-c_{i+1}|$ is absolute value of differential operation, $\left|c_i-(c_{i+\frac{n}{2}-1}\cdot c_{i+\frac{n}{2}+1})\right|$ is absolute value of symmetric structure differential operation, and $\left|c_i-c_{i+\frac{n}{2}}\right|$ is the opposite absolute value of differential operation, called time micro model (SMP) analysis method in this paper. Equation (10) said in the current position's difference between c_i and $(c_i\cdot c_{i-1}\cdot c_{i+1})$. This paper calls on itself. Define as self derived coded formula. Its features are as follows: if $c_i=0$, then $\chi=0$, If $c_i=c_{i-1}=c_{i+1}=1$, then $\chi=\alpha-1$ the formula $|c_i-c_{i+1}|$ is used to measure the micro characteristic variables of successive poor score. Based on knowledge, these variables are very useful information in the micro characteristics, so that means they must be used to measure the alternating pattern. The proposed method is different from LBP in a cycle moves to the right of n rotation invariant method.

To construct global histogram H, to take χ^2 the test data is very common:

$$R_{i,j}=\frac{1}{2}\sum_a\sum_b\frac{[H_i(a,b)-\mathrm{H}_j(a,b)]^2}{H_i(a,b)+H_j(a,b)} \tag{11}$$

Among them, H_i and H_j are on behalf of the DAFT histogram.

2.5. The Whole Process Algorithm

K square clustering is one of the simplest unsupervised learning algorithms; it can solve the problem of famous cluster. The steps to follow a simple and easy way, by an appropriate number of clusters (set to k group clusters) to classify the data set is given. The main idea is to define k group image sets, corresponds to the cluster k group, the placement of these images focused heart need clever because different placement will cause different results. So, the better choice is to place them far away from each other. The next step is to find belongs to each point of the given data, then it and joint the recent image and heart. When there is no point is pending, completed the first step, and early age group is completed. In this regard, by step results k group on the center of the new figure need to be calculating again as a center of gravity.

The whole process of the proposed method is shown in figure 5, first, cut into the $m\times n$ size of all the training images, then the image is divided into several with $p\times q$ size and non-overlapping local small pieces, then using local model for texture coding, measurement of similarity distance transformation or k-means clustering algorithm to classify each image, read a test image, for the same operation, calculating the test image and the Euclidean distance between the training images, and finally, using the K neighbor classifier to complete human face recognition.

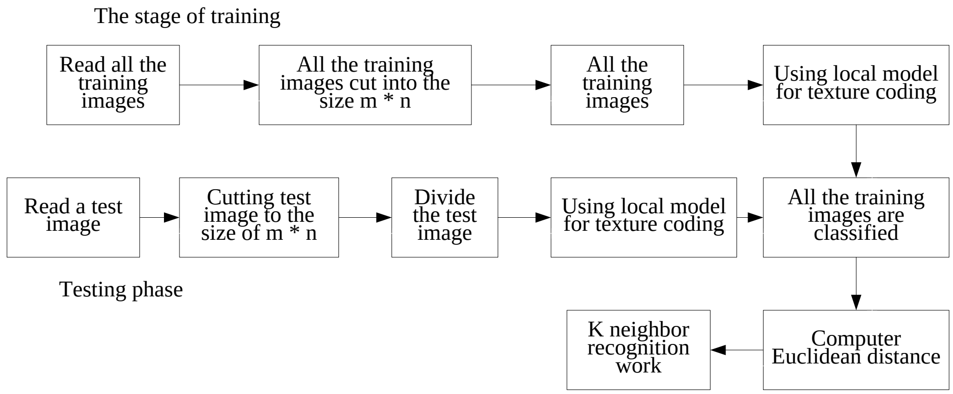

Figure 5. Implementation of Proposed Method

3. Experiment

3.1. Experimental Conditions

Yale face repository contains 15 individual 165 faces, 11 per person, including the different light conditions (light left and the right light, exposure to middle), different facial expressions (normal, happy, depressed, and fall asleep as well as the blink of an eye, surprise), different scenarios (with glasses and without glasses), as shown in figure 6 for the library of Yale face one person's 11 pair of face images with different characteristics.

Figure 6. 11 Human Face Images in the Library of Yale Face

Japan ATR (Advanced Telecommunication Research Institute International) specially used for facial expression recognition Research basic expressions JAFFE database, the database contains 213 (each image has a resolution of: 256 pixels by 256 pixels) Japanese women face phase, the expression of each image has the original definition. Expression library have total of 10 people, everyone has seven kinds of expression (neutral face, happy, sad, surprise, anger, disgust, fear). JAFFE database are positive face phase, and the original image to readjust and clip, makes the positions of the eyes in the image database is roughly same, face almost the same size, illumination are positive light, but light intensity is different, as shown in figure 7 someone's 12 different face images in JAFFE database.

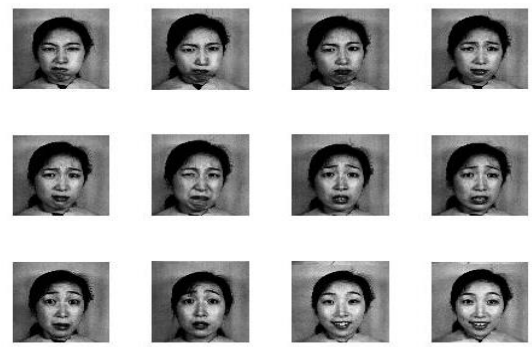

Figure 7. 12 Face Image in ATR - Jaffe Facial Repository

3.2. The Result of the Experiment

Experiment will transfer all the size of the face image into 64×64, Yale and ATR - Jaffe facial were taken in the library's first 5 images as the training images, and the rest called the test image, as the original image is shown in Figure 8 for example, shown in figure 9 for the corresponding face image after pretreatment.

Figure 8. Original Image

Figure 9. Images after Preprocessing

Experiment to the different classification of face image, respectively $7\times 7, 5\times 5, 3\times 3$, using the Texture Descriptor (Texture Descriptor, TD), using distance transformation measures and k-means clustering algorithm respectively, to calculate the distance between the database and test template, all according to the ascending order of distance, maximum 10 as the centroid, and looking for adoption patterns of duplicate values to determine the species. Experiment using k neighbor classifier, take different values k k(k=1,3,4,5, 6), Figure 10 and Figure 11 records the various cases of LBP and LTP recognition rate in Yale and ATR - Jaffe.

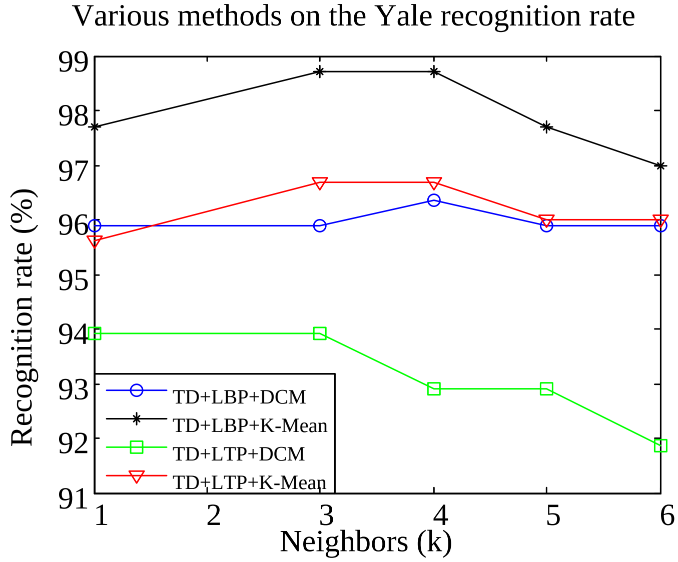

Figure 10. Each Method takes Different k Values Corresponding Recognition Rate on the Yale

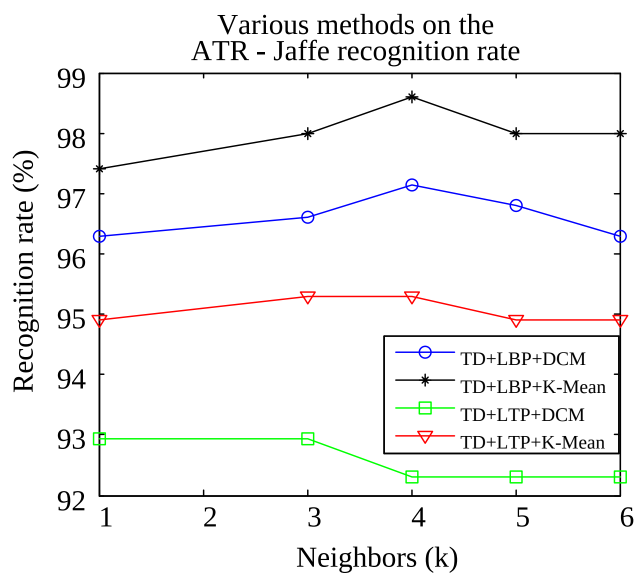

Figure 11. Each Method takes Different k Values Corresponding Recognition Rate in the ATR - Jaffe

From Figure 10 and Figure 11 can clearly see that, as the neighbor number is different, each method gets different recognition rate relatively, but the overall recognition rate is stable, the influence by k value is not large, which reflects the stability of the proposed method. Various methods at Yale and ATR - Jaffe two faces library on the best recognition rate as shown in Table 1 and Table 2.

Table 1. Face Recognition Rate of each Method on the Yale

Method	Correct recognition	Misrecognition	Misrecognition %
TD+LBP+DCM	86	4	95.56
TD+LBP+K-Mean	89	1	98.89
TD+LTP+DCM	85	5	94.44
TD+LTP+K-Mean	87	3	96.67

Table 2. Facial Recognition Rate of each Method on the ATR - Jaffe

Method	Correct recognition	Misrecognition	Misrecognition %
TD+LBP+DCM	68	2	97.14
TD+LBP+ K-Mean	69	1	98.57
TD+LTP+DCM	65	5	92.86
TD+LTP+ K-Mean	67	3	95.71

As can be seen from Table 1 and Table 2, after using the texture descriptors, and then using distance transformation measure algorithm, LBP in two faces library on recognition rate is higher than the LTP were 1.12%, 1.43% respectively, using the K - Mean clustering algorithm, LBP in two faces library on the recognition rate is higher than the LTP respectively 2.22%, 2.86%, and in all of the four kinds of cases above, using the K - Mean clustering algorithm, LBP has the highest recognition rate, on the Yale is as high as 98.89%, the ATR - Jaffe as high as 98.57. In general, LTP recognition performance is better than LBP, however, in the proposed method combines texture descriptor and LBP, LTP respectively, and respectively using distance transformation measure algorithm, the K - Mean clustering algorithm, LBP recognition performance is much better than the LTP.

3.3. Experimental Analysis

In order to better reflect the superiority of the proposed method, this part of the proposed method compares the methods of several documents, including PCA, LDA [2], LBP [4-5] LTP [7], PCA and NN, RSR [10], and [8] MMDA [11] method on ORL and FERET optimal recognition rate were compared, among them, the first five image as the training sample, the remaining as the test sample, comparing the results as shown in table 3.

Table 3. Recognition Rate Comparison of each Method on ORL and FERET (%)

Method	Yale	ATR-Jaffe
PCA	88.00	91.82
LDA	92.19	94.37
LBP	95.72	96.57
LTP	96.83	96.90
PCA-NN	97.30	96.86
RSR	97.79	97.24
MMDA	98.08	97.59
Proposed Method	98.89	98.57

From Table 3, we can see clearly that two faces at Yale and ATR - Jaffe library, the recognition rate of the proposed method was obviously higher than that of all other methods, on the Yale, proposed method is better than PCA, LDA, LBP, LTP, PCA and NN, RSN, MMDA method is of high recognition rate respectively were 8.89%, 6.70%, 3.17%, 2.06%, 1.59%, 1.10%, 1.59%, on ATR - Jaffe, the proposed method is better than PCA, LDA, LBP, LTP, PCA and NN, RSN, MMDA method is of high recognition rate respectively were 6.75%, 4.20%, 2.00%, 1.67%, 1.71%, 1.33%, 1.71%, it is enough to demonstrate the superiority of the method in this paper.

4. Conclusion

In order to solve the problem of the low rate of human face recognition under the restricted condition, this paper proposes a face recognition method based on local pattern texture descriptor. First will all face image clipping, division, and use the local texture descriptor for coding, introduces a distance conversion metric algorithm and the k-means clustering algorithm, two general face at Yale and ATR - Jaffe database, analyzes the LBP and LTP recognition performance under different conditions, and compared with several other state-of-the-art methods. Experimental results show that the proposed method not only has strong stability, also enables the identification of LBP in significantly more than the LTP, two faces at Yale and ATR - Jaffe database on recognition rate is significantly higher than other methods.

Analysis shows that when k mean square clustering algorithm is used, to improve the recognition rate significantly. Introduced the texture descriptor, combined with LBP, distance measurement algorithm and K - Mean algorithm, greatly improve the human face recognition rate, but certain overhead is inevitable, therefore, under the premise of how to improve the recognition rate, improve the efficiency of the algorithm, will become a study emphasis in further research. Will, moreover, after the LBP texture descriptor combined with other algorithms, the classifier, and the other on the database of the experiment, to further improve the recognition performance.

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