Face Recognition Based on Euclidean Distance and Texture Features

Jiali Yu
Department of Electronic and Information Engineering
Nanchang University
Nanchang China
e-mail: fish.yu87@hotmail.com

Chisheng Li
Department of Electronic and Information Engineering
Nanchang University
Nanchang China
e-mail: chishengli@163.com

***Abstract*—As a kind of statistical features, texture features often have a rotary deformation, and have strong resistibility to noise. The paper first constructs the gray level co-occurrence matrix of face image to describe texture feature of face image, and then uses the classification method of minimum weighted Euclidean distance to fulfill the matching and identification of face. Experiments results have shown that recognition rate was greatly increased by the combination of weighted Euclidean distance and texture feature.**

Keywords-texture features; gray level co-occurrence matrix; Euclidean distance; face recognition

I. INTRODUCTION

With the continuous advancement of the society as well as an urgent requirement for fast and efficient automatic identity verification, biometric technology has developed rapidly in recent years. Bill Gates has predicted that: "human biometrics - fingerprint, language, facial way to verify biometric technology in the next few years will be the most important technological revolution in the IT industry"[1]. As one of the most friendly biometric identification technology, face recognition technology attracts more and more attention because of its application prospects in a wide range of national security, military security and public safety field. The analysis area of the skin texture is unique (wrinkles, pigmentation, and other optional features), which requires high resolution. Texture features is a global feature and different from color feature. Texture features is not based on the pixels, it needs statistical calculations which occurs in multiple pixel area. Such regional characterized feature has great advantage in the face matching and will not lead unsuccessful match which due to partial deviation.

In the early 70s, Haralick [3] proposed the gray matrix texture. The method that considers the gray level's spatial dependency in image's texture and according to the azimuth and distance relationship between image pixels to construct co-occurrence matrix, is still have a very wide range of applications. This paper presents a face recognition method based on Euclidean distance and image texture features, mainly through extracting face image texture features which are based on gray level co-occurrence matrix and determining the minimum Euclidean distance to achieve accurate face recognition.

II. GRAY LEVEL CO-OCCURRENCE MATRIX

There are three methods used to describe the region texture in image processing, statistical, structures, and spectral methods. GLCM is a texture analysis methods based on statistical theory, which has been proved to be a good way of image texture analysis to describe the spatial correlation of pixel gray texture.

GLCM is a joint probability matrix based on the image gray, which is indicated by calculating image close neighbors like Yuan gray levels between the second joint conditional probability densities. An image's GLCM reflects image gray's integrated information on direction, adjacent interval, the magnitude of changes.

Making Δx, Δy represents the relative position between the two pixels and considering an image f having L possible gray levels. Let G be a matrix, whose element g_{ij} represents the number of times of the pixels in f. The gray level of the pixels are $f(x,y) = i$ and $f(x + \Delta x, y + \Delta y) = j$, $0 \le i,j \le L - 1$. A matrix formed by this method is called GLCM, its formula may be expressed as:

$$g_{ij} = N\{(x,y) \mid f(x,y) = i \,\&\, f(x+\Delta x, y+\Delta y) = j\} \tag{1}$$

$$G = \begin{pmatrix} g_{0,0} & \cdots & g_{0,L-1} \\ \vdots & \ddots & \vdots \\ g_{L-1,0} & \cdots & g_{L-1,L-1} \end{pmatrix} \tag{2}$$

N represents the number of the pixels that are qualified with conditions, $f(x,y)$ is the gradation level of the pixel at the point (x,y), Δx, Δy reflect the distance d and direction θ between two points. As shown in Fig. 1.

Thus, if d and θ represent different number combinations, we can obtain different GLCM under different conditions. The values of d and θ should be selected according to the characteristics of texture cycle distribution, when d and θ are small, corresponding to the slowly changing the texture image, the numeric value on the diagonal of its GLCM is larger. If the texture changes accelerate, then the values on the diagonal decrease, while the elements in the diagonal lines on both sides increases. The size of GLCM which is generated by a 256 grayscale image is 256 * 256, due to the GLCM is proportional to the size of gray level, the amount of calculation is very large. In order to reduce the computational burden, before calculating GLCM, we usually compress the image gray level; quantify it as 16 or 32. There

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is a slight distortion in series reduced graphics, but has little effect on texture analysis.

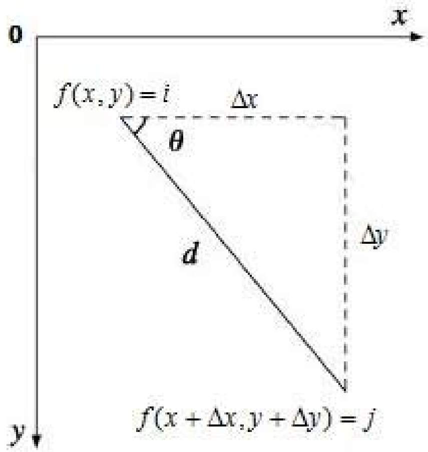

Figure 1. Schematic diagram of GLCM

III. TEXTURE FEATURE VECTOR

As the GLCM can not be directly used to describe the image texture features, therefore, in order to be able to describe the nature of the image texture, but also need to define some statistics to describe the texture features, we use following characteristic parameters.

- Consistency (also known as energy)

$$Q_1 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1} p_{ij}^2 \quad Q_1 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1} p_{ij}^2 \tag{3}$$

Consistency is also known as the energy, it reflects the image uniformity and texture coarseness of the image gray distribution; coarse texture has more energy than fine texture. The range of the values of consistency measure is [0, 1], For constant image, the consistency is 1.

- Contrast

$$Q_2 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1}(i-j)^2 p_{ij} \tag{4}$$

Contrast reflects clarity, i.e. the fineness of the texture image, it's a contrast measure that a pixel in the entire image and the adjacent gradation. If the grooves of the image texture are deep, then the contrast is large, and the image is clearer, conversely, more blurred.

- The correlation

$$Q_3 = \sum_{i=0}^{L-1}\sum_{j=0}^{L-1}\frac{(i-m_r)(j-m_c)p_{ij}}{\sigma_r\sigma_c} \tag{5}$$

Correlation reflects the similarity of the GLCM elements in a row or column direction, it's a measure of a pixel in the entire image and the degree of its neighbors. When the image has texture of a certain direction, then GLCM's correlation value of that direction is larger than other's.

- Entropy

$$Q_5 = -\sum_{i=0}^{L-1}\sum_{j=0}^{L-1} p_{ij}\log_2 p_{ij} \tag{6}$$

Entropy reflects the amount of information the image has, and indicates the density level of the image texture. When the image texture is dense, entropy is large; texture is sparse, the entropy is small.

In the above equations, $p_{ij} = g_{ij}/n$, $\sum_{i=0}^{L-1}\sum_{j=0}^{L-1} p_{ij} = 1$, $m_r = \sum_{i=0}^{L-1} i \sum_{j=0}^{L-1} p_{ij}$, $m_c = \sum_{j=0}^{L-1} j \sum_{i=0}^{L-1} p_{ij}$, $\sigma_r^2 = \sum_{i=0}^{L-1}(i-m_r)^2\sum_{j=0}^{L-1} p_{ij}$, $\sigma_c^2 = \sum_{j=0}^{L-1}(j-m_c)^2\sum_{i=0}^{L-1} p_{ij}$.

For each d and θ, we can calculate and obtain a face image GLCM 4D eigenvectors. Therefore, according to the different value of d and θ, the plurality of four-dimensional feature vectors can be obtained. As the feature of face image is fine, so d values 1, θ values 0°, 45°, 90°, 135°.

Constructing corresponding GLCM according to four directions and then calculate the corresponding metric and sequentially weighted average processing to obtain a final four-dimensional feature vector. Fig. 2 displays the GLCM on four directions of the right face, gradation is compressed to 16.

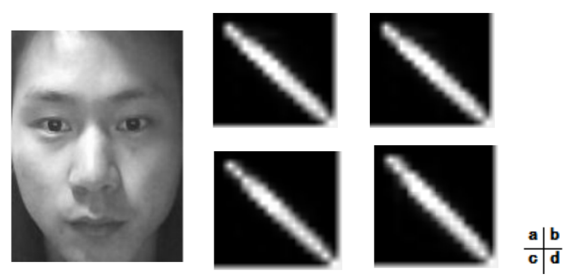

Figure 2. the GLCM of 16 *16

TABLE I. VALUES OF DIFFERENT DIRECTION

Direction	*Consistency*	*Contrast*	*Correlation*	*Entropy*
0°	0.051331	0.377584	0.088124	3.321788
45°	0.042790	0.603757	0.087384	3.518050
90°	0.051245	0.341966	0.087498	3.311137
135°	0.043399	0.547151	0.087615	3.503249

Further, since the meaning of the various features of the image and the different units, there are differences in classifying the image correctly, and therefore also need all features of the normalization processing, so that the respective components of the feature vectors have the same weight.

IV. Face recognition Based on Euclidean Distance and Texture Features

Common classification of texture features: distance classification, clustering classification, support vector machine classification and neural network classification. Minimum Euclidean distance taxonomy is a classification based on the distance of the Euclidean distance; the algorithm is simple, easy to implement features [7].

Euclidean distance (Euclidean distance) is defined as:

$$D(x,y)=(\sum|x_i-y_i|^2)^{\frac{1}{2}} \tag{7}$$

Euclidean distance, however, did not take into account the relationship between each dimension of the vector, and the requirements of each dimension is equally important, which greatly affect the scope and effectiveness of its use. As the importance of extracted face feature vectors is different, we use the weighted Euclidean distance measure in order to ensure the accuracy of identification.

$$D(x,y)=(\sum_{i=1}^{4}w_i|x_i-y_i|^2)^{\frac{1}{2}} \tag{8}$$

For i=1,2,3,4 are four corresponding Eigen values, x_i , y_i are texture feature vectors.

For face recognition, collect a large number of people face training samples firstly and extract texture features, establish the facial feature template library, and then calculate weighted Euclidean distance of each face on face database that to be identified, when $D(x,y)$ is smaller than a certain threshold value, then this face will be identified.

V. Experimental Results and Analysis

In order to verify the real-time and accurate rate of face recognition that conducted through GLCM texture feature, we use the above algorithm to create a system based on Visual C# platform and test 2099 pairs of face photos selected from the existing database randomly. Among them, two pairs of photos are not the same person than exchanged. We should pre-process the image before testing and use median filters denoising, then histogram equalizes the image to remove the light effects and enhances the image contrast. The test results showed in the following table:

TABLE II. The Test Results

No	*Project*		*Parameter*	
1	Algorithm		Euclidean distance +texture feature	
2	Modeling time		2.2l/se（0.456se/l）	
3	Template size		9KB	
4	Comparison (verification speed)		2.2 l/se （0.456 se/l ）	
5	Total number of query set		2099	
6	Total number of goal set		2099	
7	The number of the strike	2095	The rate of the strike	99.8%

From the test results, we can see that the face recognition system can identify 2095 pairs of photos effectively from 2099 pairs of photos; the recognition rate is 99.8%. The four pairs of photos are identified as not the same person, two pairs are identified correctly, and the others are misidentified. It's visible that the correct rate of the same person is 100%. There are some deviations in the test results for the photos that are not the same person, so the results should be reviewed manually; however, the manual intervention rate is only two thousandths. Therefore, we can achieve real-time and accurate automatic face recognition through the above face recognition algorithm.

VI. Conclusion

This paper extracts facial texture features based on GLCM and uses weighted Euclidean distance to determine the degree of similarity of the human face, we can achieve real-time and accurate face recognition at some extent. But as the texture features are particularly susceptible to the resolution of the image, when the resolution changes, the calculated textures are not accurate, therefore, the face recognition that uses texture features requires high quality images. When the image is blurred, the identification is relatively poor, and that's what we need to improve.

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