

Iris Recognition Using Spatial Pyramid

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Abstract—Importance of biometric user identification is increasing everyday. In recent years, the iris recognition technology is considered to be one of the most promising biometric recognition technology. The selection of iris features has become an important issue in the field of iris recognition. In this paper, the spatial pyramid matching of the scene classification for iris images is proposed. Firstly, introduce the definition of spatial pyramid matching, and then introduce how to use it for iris feature extraction and iris matching. Experimental result shows the proposed method used for iris recognition is efficient.

Keywords—spatial pyramid; iris recognition; feature extraction; biometric recognition

I. INTRODUCTION

In recent years, with the development of information technology and the increasing need for security, intelligent personal identification has become a very important topic. Biometric recognition technology is based on the human inherent physiological or behavioral characteristics for identification. Biometric characteristics have face, voice, fingerprint, iris, etc. Nowadays a lot of biometric techniques are being developed based on different features and algorithms [1]. Each technique has its strengths and limitations; it is difficult to determine which one is the best. Compared with other biometric characteristics, iris has unique characteristics like stability throughout life time. Iris organization has rich details, the probability of uniqueness is very important for identification. In this paper, the spatial pyramid matching of the scene classification for iris images is proposed. After iris image pre-processing, use spatial pyramid to extract iris feature, then combine with the average histogram when feature matching. Experimental result shows the algorithm is efficient.

The remainder of this paper is organized as follows. Related work is presented in Section II. Section III details the proposed method. Extensive experimental results are presented and discussed in Section IV prior to conclusions in Section V.

II. RELATED WORK

Plenty of works are done on Iris Recognition System. J. Daugman [2] proposed an algorithm by using Gabor wavelets for feature extraction in 1993. The paper concretely carried out analysis of detail of this method, and showed the concrete parameter design of the filter of Gabor that can

extract character information effectively, the way to quantize codes, and the method of character match. R. Wildes [4] used Laplacian pyramid to represent the distinctive spatial characteristics of the iris. He gave a way to shorten its huge character vector space. Match the character information that extracted in the most simple way, obtained a good iris identification effect. W. Boles proposed a one-dimensional dyadic wavelet transform [5] to obtain the zero-crossing representation. Kong and Zhang presented a noise detection model in [6]. Tisse et al [7] proposed a segmentation method based on integro-differential operators with a Hough Transform. This reduced the computation time and excluded potential centers outside of the eye image. Eyelash and pupil noises were also not considered in his method.

III. BASIC PRINCIPLE OF SPATIAL PYRAMID MATCHING

Generally speaking, pyramid matching divide the feature space into a continuous size-growing grid at a series of layers. Finding out the matching point of each layer and using the weighted sum of all layers as the similarity measurement. The matching condition of two points is that they fall into the same grid at the same time. Matching points found in the small grid of the layer have much more value than those points which found in the larger grid. The following is a detailed definition of spatial pyramid matching:

Define X and Y both are D dimensional vectors. Construct a series of grid layers, named $0, 1, 2, \dots, L-1$. Assuming that every dimension has 2^l grids, so the total number in the l_{th} layer is 2^{Dl} . Using H_x^l and H_y^l to represent the matching points histogram statistics in the l_{th} layer of X and Y vector respectively. So $H_x^l(i)$ and $H_y^l(i)$ represent the numbers of X and Y fall into i_{th} and l_{th} layer. The matching points in l_{th} layer are defined as the following:

$$\ell(H_x^l, H_y^l) = \sum_{i=1}^D \min(H_x^l(i), H_y^l(i)) \quad (1)$$

ℓ^l is short for $\ell(H_x^l, H_y^l)$ there we used.

Must pay attention to is that the matching points found in the l_{th} layer are also matched in larger grid layer $(l+1)_{th}$ at the same time, so new matching points found in l_{th} becomes $\ell^l - \ell^{l+1}$, there $l = 0, 1, \dots, L-1$; matching

weighted value is $\frac{1}{2^{L-l}}$ which is connected with the size of grad in the current layer. We hope to punish those matching points which found in large grid, because of the matching feature of the large grid is much rough. Put all the factors together, we can get the pyramid matching kernel:

$$k^l(X, Y) = \ell^l + \sum_{i=0}^{L-1} \frac{1}{2^{L-i}} (\ell^i - \ell^{i+1}) \quad (2)$$

Simply the equation:

$$k^l(X, Y) = \frac{1}{2^L} \ell^0 + \sum_{i=0}^{L-1} \frac{1}{2^{L-i+1}} \ell^i \quad (3)$$

An example of spatial pyramid matching on layers as shows in Fig.1

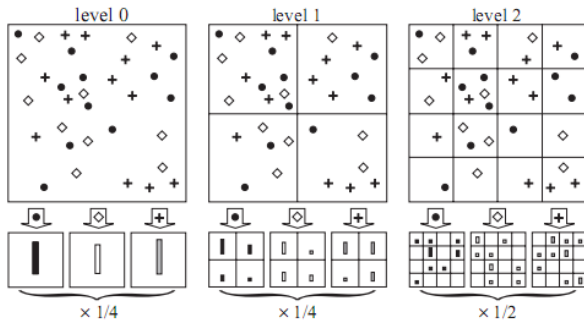


Fig 1.

In Fig.1, we construct a three layers pyramid to help for understanding the theory. There are characteristics in the picture: circle, diamond, crosses. First of all, we divide the picture into three layers, then computing feature points in each layer and each channel, at last, weighted it according to the weighted formula.

IV. IRIS FEATURE EXTRACTION USING SPATIAL PYRAMID

The method we proposed for Iris feature extracting is using the theory above to do pyramid matching between two iris images. According to its similarity to determine whether it is the same iris.

A. Iris Feature

After the normalization, transforms an iris image to a 64×512 rectangular graphics shown in Fig.2, the task is to extract texture information from normalized image and use the feature vector for iris matching.

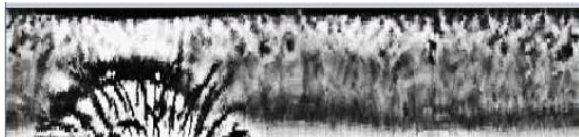


Fig 2. Normalized iris image

1) Iris Subgraph

Operate the image by using the sobel operator to find out the corresponding gradient image. w_1 and w_2 represent 0° and 90° direction sobel operator respectively. I_x represents the iris image through filter w_1 , I_y represents the iris image through filter w_2 . Therefore the gradient image is: $I_g = \sqrt{I_x^2 + I_y^2}$. At the same time, calculate the phase image of the other iris image. The following formula can be used: $A = \arctan \frac{I_y}{I_x}$. Then create a binary image from

I_g with a threshold. After get the phase image, dividing the binary gradient image into 8 subgraph according to the phase direction. The aim is to improve the distinguish phase of features. Then Construct the subgraph with gradient image and phase image:

In the 64×512 rectangular, pixels value is equal to 1 whose gradient value is 1 and phase value is between $(0, \frac{1}{4}\pi]$ at the same time, so we can construct a new subgraph i_1 . In the same way, construct new subgraph i_2 when phase value fall into $[\frac{1}{4}\pi, \frac{1}{2}\pi)$ and do like this. And, we can construct 8 subgraphs (i_1, i_2, \dots, i_8) .

2) Feature Extraction

Extract the 8 subgraphs' feature by using spatial pyramid, divide a subgraph such as i_1 into 4 layers, the size of grid at n_{th} layer ($n=0,1,\dots,L-1$) is $2^{n+2} \times 2^{n+2}$ pixels, on this layer contains $\frac{64}{2^{n+2}} \times \frac{512}{2^{n+2}}$ grids. For example, the size of grid at 0_{th} layer is 4×4 pixels, the 0_{th} layer contains 16×128 grids. Then count feature points in histogram graph from 0_{th} layer, feature points must be counted independently in each grid. Then divided by subgraph total feature points and get the normalized feature value which is very important for feature matching. Each grid's feature value forms a one dimension in feature vector. Therefore, get 4 vectors from the 4 layers and their length are 2048, 512, 128, 32 respectively. And there are eight subgraph. So the 32 vectors are used to represent one iris image.

B. Iris Matching

In the matching process, we use the similarity calculation principle to calculate the similarity of two iris images. The similarity value is larger. After a lot of iris sample experiment, find out a threshold value of similarity for distinguishing whether it is the same iris image. If the similarity is larger than the threshold value, then these two iris images come from one person.

Define $\vec{a}_i, \vec{b}_i, \vec{c}_i, \vec{d}_i$ (there $i=1,2,\dots,8$) represent the 8×4 one dimension vectors which got through spatial pyramid method. The length of \vec{a}_i is 2048, its each value represent the feature histogram statistics of a grid on 0_{th} layer. \vec{b}_i represent the 1_{th} layer's and so on. $\vec{a}'_i, \vec{b}'_i, \vec{c}'_i, \vec{d}'_i$ Represent the feature vector used for matching. For example, the calculation of similarity the 0_{th} layer is:

$$lv_0 = \text{sum}(\min(\vec{a}_i, \vec{a}'_i)).$$

Here function min is choose the small value in each dimension of \vec{a}_i and \vec{a}'_i , and sum will plus each small value in dimension to all. According to (1) we use weighted to publish large grid. Therefore, the summed similarity is:

$$\text{sim} = lv_0 + \frac{1}{2}(lv_1 - lv_0) + \frac{1}{4}(lv_2 - lv_1) + \frac{1}{8}(lv_3 - lv_2) \quad (4)$$

V. EXPERIMENT

In our iris image database, there are 12000 images from 600 individuals.

Selection of within-class sample: choose the beginning 10 images for matching with the ending 10 images of one person. The 600 individuals' images are all used.

Selection of between-class sample: choose 30 persons for matching with another 200 persons respectively.

A. Gradient Threshold Value Selections

In order to obtain the best extraction effect, we have done four groups experiments to choose the gradient threshold value. Fig.3 shows the corresponding ROC curve.

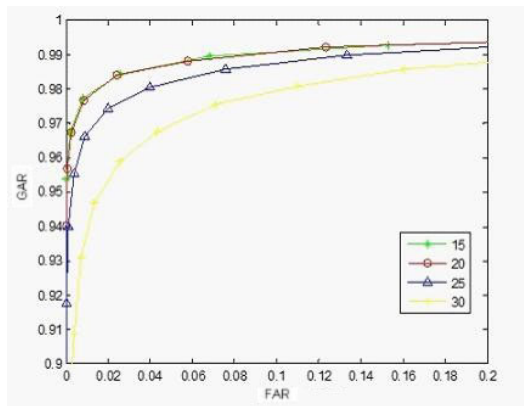


Fig 3.

The ROC curve shows experiment can get the best feature extraction performance when the gradient threshold value is 20.

B. Algorithm Performance Analysis

When threshold value is at the intersection of similarity (when $T=0.415$), in the 12000 times matching experiments, false reject 421 times, false accept 323 times, algorithm

False Reject Rate (FRR) is 7.01%, False Accept Rate (FAR) is 5.38%. At the intersection of FRR and FAR curve, the Equal Error Rate (EER) is 6.5%, the threshold value is 0.413 at the same time. As shows in Fig.4, the simulation result demonstrates that our method can realize the iris classification well.

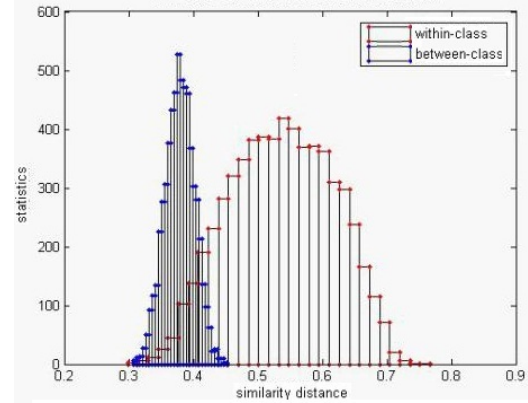


Fig 4.

C. Comparison With Other Algorithms

In experiments, the Average Histogram is always combined with other algorithm to improve the precision of feature matching. Fig.5 shows the ROC curve analysis between Gabor wavelets, Spatial Pyramid, average histogram with Spatial Pyramid.

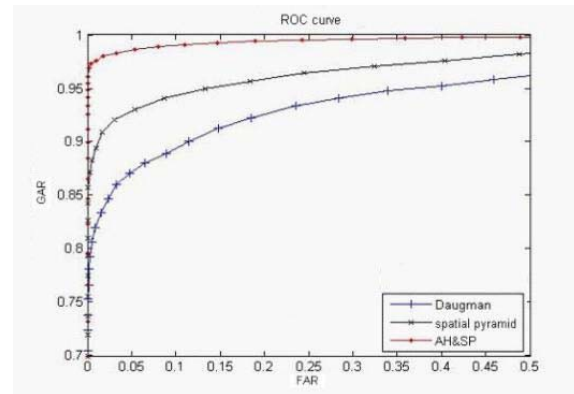


Fig 5.

From the ROC curve above, the method of extracting feature by spatial pyramid method can get low false rate than Daugman's method. In addition the experiment proved that using average histogram algorithm with spatial pyramid can achieve better performance while feature matching.

When the FAR approach to zero, the spatial pyramid algorithm can obtain the highest GAR. The above experiment result shows that the proposed method is better than the other algorithm. Using Spatial Pyramid to extract iris feature can get high precise recognition effect. And using

the Average histogram at feature matching can improve the algorithm matching effect significantly.

VI. CONCLUSIONS

A person identification technique using human iris recognition is presented in this paper. And the Spatial Pyramid method achieves very good results in feature extraction. Experimental result shows the proposed method used for iris recognition is much more efficient. The gradient parameters setting can be improved in feature extraction, such as the selection of eight regional phases. Our future work will concentrate on it for achieving a more robust recognition.

VII. REFERENCES

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