REDUCING THE EFFECT OF PARTIAL OCCLUSIONS ON IRIS RECOGNITION

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Abstract: The difficulty in the process of human identification by iris recognition is that the iris images captured may have occlusions by the eyelids and eyelashes. In that case, recognition of occluded iris patterns becomes hard and the corresponding person may not be correctly recognized. In order to reduce the effect of eyelid or eyelash occlusion on the recognition of human beings by their iris patterns, we propose a simple and efficient method for iris recognition using specific regions on the iris images without using the traditional preprocessing approach before applying the feature extraction method to recognize the irises. First of all, these regions are individually experimented and then the outputs of each region are combined using a multiple classifier combination method with the feature extraction method Principal Component Analysis (PCA). The experiments on the iris images, with and without occlusions, demonstrate that the proposed approach achieves better recognition rates compared to the recognition rates of the holistic approaches.

1 INTRODUCTION

Reliable person identification or verification is becoming a very important topic in recent years in most of the countries in the world. Biometrics is a popular field of study which is related to the recognition of individuals based on their physiological and/or behavioral characteristics. Iris recognition is one of the most secure and reliable biometric recognition systems (Ma *et al.,* 2004; Cui *et al.*, 2004; Daugman, 2006) to recognize human beings. It is not suitable to get iris images of people in each condition and enviroment to recognize human since the iris images must be captured by a special camera from people who are willing to do this. However, for controlled enviroments such as airports, iris recognition seems to be a convenient biometrics to identify human beings.

The difficulty in the process of human identification by iris recognition is that the iris images captured may have occlusions by the eyelids and eyelashes. In this respect, recognition of occluded iris patterns becomes hard and the corresponding person may not be correctly recognized.

In order to reduce the effect of eyelid or eyelash occlusion on the recognition of human beings by their iris patterns, we propose a simple and efficient method for iris recognition using specific regions on the iris images without using the traditional preprocessing approach before applying the feature extraction methods to recognize the irises. In our method, the iris image is partitioned into vertical left and right regions and also top and bottom regions of the iris are partitioned horizontally into two regions. In this way, the horizontal or vertical regions of the iris pattern without including the pupil is obtained from the iris image. Firstly, these regions are individually experimented on the CASIA iris dataset and the recognition rate of each region is recorded using Principal Component Analysis (PCA) as the feature extraction method. Then, an appropriate multiple classifier combination method is used to combine the output of these regions. Various experiments are performed to test the recognition performance of the classical and the proposed approaches using iris images with and without occlusions on different regions of the irises. The results are presented in the further sections.

The rest of the paper is organized as follows. Section 2 describes PCA which is the feature extraction method used in this study. The proposed approach for iris recognition based on the partitioning method is described in Section 3. The

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experimental study and the discussions are presented in Section 4. Finally, Section 5 concludes the paper.

2 FEATURE EXTRACTION METHOD

Appropriate feature extraction is an essential component of a successful biometrics recognition algorithm. For this purpose, statistical dimensionality reduction methods such as Principal Component Analysis, Linear Discriminant Analysis and Independent Component Analysis are demonstrated to be successful in several academic studies and commercial applications (Toygar and Acan, 2004, Chu and Chen, 2005). The success and popularity of these algorithms are mainly due to their statistics–based ability of automatically deriving the features instead of relying on humans for their definitions. These algorithms are widely studied for the recognition of human beings using their physiological characteristics such as the face, iris, fingerprint and so on.

In this study, we apply PCA which is one of the most popular methods used in the literature for feature extraction on different regions of the iris images. PCA projects images into a subspace such that the first orthogonal dimension of this subspace captures the greatest amount of variance among the images and the last dimension of this subspace captures the least amount of variance among the images (Kirby and Sirovich, 1990; Turk and Pentland, 1991). In this respect, the eigenvectors of the covariance matrix are computed which correspond to the directions of the principal components of the original data and their statistical significance is given by their corresponding eigenvalues.

3 PARTITIONING APPROACH ON IRIS RECOGNITION

Partitioning approach for the iris recognition problem is applied by dividing the iris images into four segments and the features of each segment are extracted independent of each other using PCA method.

All the training and testing face images used in the experimental study are cropped as shown in Fig.1. Cropping operation is applied in the same way for both the training and test images, so that all the images include only the iris and the pupil after this operation. Partitioning approach is applied after this operation and divides the image into four segments, each segment including the horizontal top, horizontal bottom, vertical left and vertical right regions of the iris excluding the pupil from the iris as shown in Fig.1. In this way, the iris patterns of the training and test images are stored in four different partitions or segments.

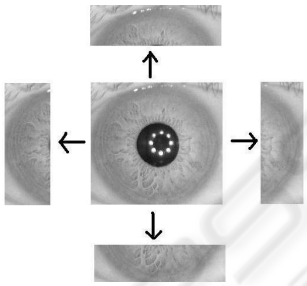

Figure 1: Partitions of an iris image: left, right, top and bottom regions.

After applying PCA algorithm on each segment of training and test images, Euclidean distance measure is used to find the distance between features of these image segments. For each test image, the distances between the test image and all the training images are compared. The training image that has the minimum distance to the test image is the image that mostly resembles to it.

In this study, PCA is implemented with a divide-and-conquer strategy for the solution of the iris recognition problem. The divide-and-conquer approach implemented over multiple classifier systems (MCSs) (Ho *et al.,*1994*;* Kittler *et al.,*1998) is used to improve the computational efficiency and recognition performance of PCA method on the iris recognition problem. MCSs combine the output information provided by two or more classifiers.

In the implementation of the divide-and-conquer methodology for the iris recognition problem, iris images are divided into two horizontal (top and bottom regions) and two vertical (left and right regions) segments and PCA is applied on each iris segment as a feature extraction method. Consequently, a multiple classifier system is established based on a particular distance measure. Finally the outputs of multiple classifiers are combined using a well-known multiple classifier combination method to recognize the whole iris under occlusions.

4 EXPERIMENTAL RESULTS

The experiments were done on the iris images chosen from the third version of CASIA iris dataset

(CASIA-IrisV3). The performance of the proposed approaches are tested using PCA algorithm applied on the individual regions of the iris images. PCA approach is applied in the same way as explained in (Toygar and Acan, 2004). In this study, the iris images used are cropped so that they only include the iris and pupil regions. The iris images were scaled down to 199x156 pixels from the original size of 640x480 pixels. The experiments were done using 100 training and 100 test images (two samples per person).

In the implementation of the proposed approach, multiple classifiers are considered using the Majority Voting classifier combination method. The output of each individual classifier is computed separately, followed by the multiple-classifier combination procedure which produces the final classifier or recognition output. Majority Voting method selects the class which receives the largest number of votes as the majority decision (Kittler *et al.,*1998). In case of equality of the votes, one of the classifiers with maximum number of votes is selected arbitrarily.

Four set of experiments are performed and the results are presented in Table 1 through Table 4. The recognition rates of the holistic PCA (PCA applied on the whole iris image), partitioned PCA (PCA applied on the four regions of the iris image individually) and the proposed approach (combination of the four regions using a MCS) are recorded. The results are presented using the images without occlusions and the images with occlusions on the training and test images.

In the first set of experiments, the whole iris images are experimented using the holistic PCA method, partitioned PCA on the left, right, top and bottom regions individually and the proposed approach to combine the outputs of each individual region of the iris image.

As shown in Table 1, the recognition rate using the holistic PCA method is 84% and the three partitioned PCA methods achieves less than this recognition rate while partitioned PCA applied on the bottom region of iris achieves 88% which is better than the holistic counterpart. Additionally, the proposed approach combines outputs of the individual regions and the recognition rate is increased to 96% which is a significant improvement.

Table 1: Recognition rates on iris images without occlusion.

Approach	Recognition Rate (%)
Holistic PCA (Whole iris)	84
Partitioned PCA (Left)	80
Partitioned PCA (Right)	66
Partitioned PCA (Top)	78
Partitioned PCA (Bottom)	88
Proposed Approach	96

Table 2: Recognition rates on iris images with occlusions on top of the images.

Approach	Recognition Rate (%) using occlusion of			
	3%	5%	7%	10%
Holistic PCA (Whole iris)	70	80	70	66
Partitioned PCA (Left)	76	70	70	70
Partitioned PCA (Right)	76	78	82	84
Partitioned PCA (Top)	56	46	50	44
Partitioned PCA (Bottom)	54	40	40	32
Proposed Approach	80	82	76	70

Table 3: Recognition rates on iris images with occlusions on bottom of the images.

Approach	Recognition Rate (%) using occlusion of			
	3%	5%	7%	10%
Holistic PCA (Whole iris)	82	80	72	60
Partitioned PCA (Left)	80	80	66	66
Partitioned PCA (Right)	78	80	84	72
Partitioned PCA (Top)	68	62	44	38
Partitioned PCA (Bottom)	64	48	48	48
Proposed Approach	92	84	80	68

Table 4: Recognition rates on iris images with occlusions on top and bottom of the images.

Approach	Recognition Rate (%) using occlusion of			
	3%	5%	7%	10%
Holistic PCA (Whole iris)	74	72	62	52
Partitioned PCA (Left)	70	68	60	62
Partitioned PCA (Right)	80	76	78	68
Partitioned PCA (Top)	40	36	32	14
Partitioned PCA (Bottom)	36	42	24	22
Proposed Approach	74	70	68	64

On the other hand, the iris images are occluded artificially with different percentages (3%, 5%, 7%, 10%) on different regions of the iris such as the top, bottom and both of them. As an example, 10% occlusions on top, bottom, and top and bottom regions are shown in Figure 2.

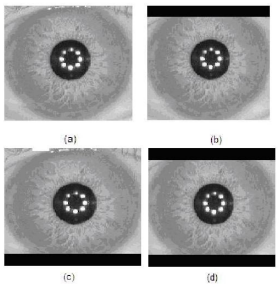

Figure 2: Iris images (a) without occlusions and with occlusions on (b) top (c) bottom and (d) top and bottom regions.

In the second set of experiments, the iris images are occluded from the top region of the iris. The recognition rates for various occlusion percentages are presented in Table 2. The data on this table shows that some of the partitioned PCA approaches slightly increase the performance of the holistic PCA. The recognition rate of the proposed approach is significantly increased compared to holistic counterparts.

The third and the fourth set of experiments also demonstrate that the proposed approach by combining the outputs of individual regions achieves better performance compared to the performance of the holistic PCA and partitioned PCA methods.

In general, the experiments using holistic PCA, partitioned PCA and the proposed approach without occlusions demonstrate that the proposed approach achieves a significant improvement for the recognition of iris images (from 84% to 96%). On the other hand, for the iris images with occlusions on either top or bottom of the iris, the recognition rates demonstrate that the proposed approach is not sensitive up to 5% occlusions. The results obtained by the proposed approach with 5% occlusions on either top or bottom of the irises are equivalent to the results obtained by holistic PCA without occlusions.

5 CONCLUSIONS

A simple and efficient approach for reducing the effect of partial occlusions and improving the recognition performance of the iris images is presented. The experiments performed using holistic PCA, partitioned PCA and the proposed approach without occlusions demonstrate that the proposed approach achieves a significant improvement for the recognition of iris images. It can also be stated that the proposed approach is not sensitive up to 5% occlusions on top or bottom regions of the iris images compared to the holistic PCA method without occlusions.

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