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Iris Feature Extraction Using Gabor Filter

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Abstract— **Biometric technology uses human characteristics for their reliable identification. Iris recognition is a biometric technology that utilizes iris for human identification. The human iris contains very discriminating features and hence provides the accurate authentication of persons. To extract the discriminating iris features, different methods have been used in the past. In this work, gabor filter is applied on iris images in two different ways. Firstly, it is applied on the entire image at once and unique features are extracted from the image. Secondly, it is used to capture local information from the image, which is then combined to create global features. A comparison of results is presented using different number of filter banks containing 15, 20, 25, 30 and 35 filters. A number of experiments are performed using CASIA version 1 iris database. By comparing the output feature vectors using hamming distance, it is found that the best accuracy of 99.16% is achieved after capturing the local information from the iris images.**

Keywords-feature extraction; hamming distance; gabor filter; iris recognition; multichannel gabor filter

I. INTRODUCTION

With the increasing security demands, it is becoming difficult to identify humans using the traditional security measures. For example, passwords, pin codes, tokens etc can be forgotten or stolen. To fulfill the high security needs, reliable person identification is a very important goal to achieve. Biometric technology is playing a vital role in accurate and reliable identification. It uses physical and behavioral characteristics of humans to identify them [1] and provides a user-friendly authentication process. The physical and behavioral characteristics include face, ear, iris, retina, speech, gait, signature etc. A lot of research has been done on the biometrics technology in the past.

Iris recognition is a reliable biometric technology. During the last few decades [2] many researchers have moved to this biometric technology. Iris is an internal human organ that lies inside the human eye. It contains very discriminating features that can be used for reliable identification of humans. The iris features of twins, and even two irises of the same person differ a lot in their textures [3]. Another big advantage of using iris as a biometric is that its texture does not change with human life as is the case with some other biometric. Iris texture remains stable over human life time and hence gives the high accuracy rates. An Iris recognition system comprises of different steps: image acquisition, iris localization, iris normalization, feature extraction and classification.

The remaining paper includes: Section II discusses the previous approaches to extract iris features, section III describes the methodology used in this work, section IV summarized results and a discussion about these results, and conclusion is made in section V.

II. BACKGROUND

The current research is focused on the iris feature extraction stage. It is the most critical step of the recognition process. During this step, the discriminating iris features are extracted from the input image and converted into a coded form. Different techniques have been implemented for this purpose during the last few years.

John Daugman [4] is the pioneer of the iris recognition era. He has used 2D gabor filter to extract iris features. After extracting the unique features, he converted the feature vectors to binary form and generated a bit code of 2048 bits. Then he used hamming distance as classifier to compare the binary feature vectors. A lot of work in this era has been done by Li Ma. He used [5], [6] gabor filter in another way to extract the iris features. He applied the gabor filter on local parts of an image. Then he combined the local information to global feature vectors and compared them. In another experiment, Li Ma [7] used gabor filter in a different form called circular symmetric filter to extract the iris features. In this work, he used circular symmetric filter to extract local iris features and combined this local information to form global feature vectors. Some other researchers used wavelet transform for feature extraction.

III. METHODOLOGY

In this research, gabor filter is applied on input images in two different ways. In the first approach, a 2D gabor filter is applied on the entire image, and in the second approach, multichannel gabor filter is applied locally on parts of image. These techniques are tested using CASIA version 1 iris database. Iris localization of these images was performed using a previous method described in [8].

Figure 1 shows the steps involved for iris recognition using gabor filter.

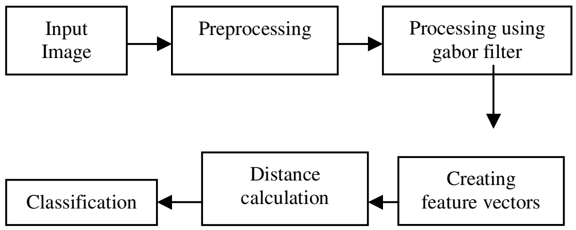

Figure 1. Flow of the system using gabor filter as recognition technique.

Figure 2 shows the steps involved for iris recognition using multichannel gabor filter.

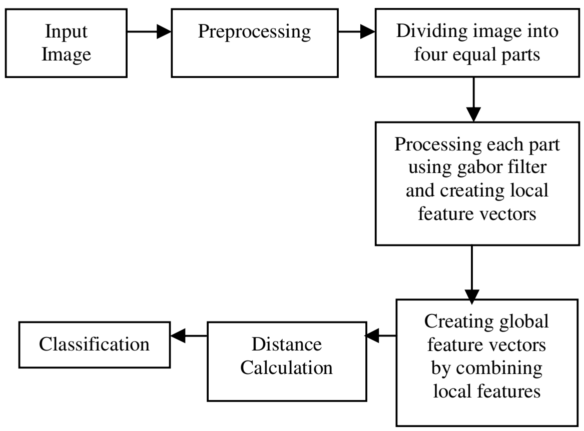

Figure 2. Flow of the system using multichannel gabor filter as recognition technique.

A. Pre-Processing of Input Images

Before extracting the discriminating iris features, a pre-processing step is performed on the input images. As mentioned above, the normalized iris images are used in this work. These normalized images are usually of low contrast because the position of the light changes when the human eye image is captured. And due to this light illumination, the input image contains some noisy information that can cause diverse effect on recognition result. To handle this problem, each input image is divided into small blocks of 16 * 16 pixels size using an approach described in [9]. The mean of each block is computed that represents the background illumination. This mean value is expanded to the entire image size using the bicubic interpolation. This way, an image consisting of background illumination is created and subtracted from the original image. This pre-processing step is applied on all images and two types of images are used in the recognition process [10]. Figure 3 represents the two types of input images.

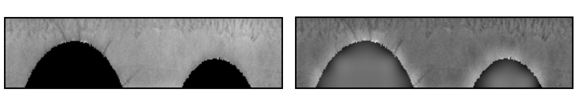

Figure 3. Input images in original form and after background subtraction.

B. Feature Extraction Using Gabor Filter

2D gabor filters are applied to extract the iris features. A number of banks of gabor filters are applied on images including 15, 20, 25, 30, 35 filters by varying the wavelengths and orientation angles of the filters. The results for each bank is evaluated and compared. 2D gabor filter is defined as:

$$G(x, y; \theta, f) = \exp\left\{-\frac{1}{2}\left[\frac{x'^2}{\delta_x^2} + \frac{y'^2}{\delta_y^2}\right]\right\}\cos(2\pi f x')$$

$$x' = x\cos\theta + y\sin\theta$$

$$y' = y\cos\theta - x\sin\theta$$

where δx and δy represent the spatial size of the filter, θ is the orientation angle, f is the frequency of the filter. Since a gabor filter has both its real and imaginary parts, when an input image is convolved with a bank of 20 filters, it yields 20 real and 20 imaginary outputs. An output feature vector of length 2048 bits is generated by combining these real and imaginary parts. This convolution process is applied to all images in the database. Figure 4 shows the real and imaginary outputs of an input image using gabor filter.

Figure 4. Resultant real and imaginary parts of an image after applying gabor filter.

C. Feature Extraction using Multichannel Gabor Filter

A number of banks are applied in a similar way as described above on iris images. But the difference lies in the application of these filters. In this method, the filters are not applied to the entire image at once, but applied locally on small parts of the image. In this way local information is calculated from each part and combined to form the global information that represents the entire iris image. The technique is implemented by dividing the original image into four equal parts. The original image is of size 64 * 256 pixels. After division, each sub-image is of size 64 * 64 pixels. Different banks of gabor filters are applied on these sub-images. Information from each sub-image is extracted and collected in a feature vector. A resultant feature vector is formed by combining the local feature vectors for both real and imaginary outputs and used for comparison.

D. Classification

Hamming distance is used as a classifier to compare the extracted iris features. The resultant feature vectors are converted to binary form and compared using hamming distance.

If X and Y represent two binary patterns, the hamming distance (HD) is calculated by taking XOR of the binary patterns and summing up them. This summation is divided by total number of bits (N):

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j$$

IV. RESULTS & DISCUSSION

CASIA version 1 database includes 756 images in 108 classes. These images are used in two different forms as mentioned above. Two experiments are performed by varying the number of training and testing images in a class.

A. *Experiment 1*

In the first experiment, first three images of a class are considered as training images and last four as testing images [10]. The two approaches are experimented using the two types of images. Table 1 shows the best results of this experiment for both cases. Case I and II represent the cases where original images and images with background subtraction are used respectively. The number of gabor filters used within a bank are also given. Threshold values that are used to separate the true and false matches are also shown.

TABLE I.

RECOGNITION RESULTS FOR EXPERIMENT 1.

Case	Method	Number of Filters	Accuracy (%)	Threshold
I	Multichannel gabor	25	98.66	0.28
	Gabor	25	98.49	0.31
II	Multichannel gabor	30	98.99	0.30
	Gabor	25	98.66	0.31

It shows that the multichannel gabor filter is giving the best result (98.99%) using a bank of 30 filters for the second case where enhanced images are used. Using gabor filter, the best result (98.66%) is obtained for enhanced images with 25 filters. Figure 5 displays a graph of the best results for experiment 1.

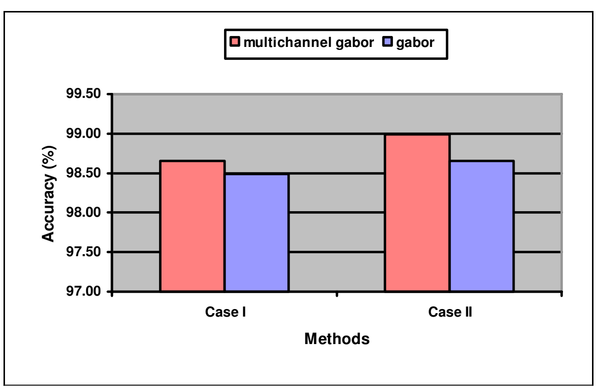

Figure 5. Best recognition results for experiment 1.

The performance of the experiment is measured using two criteria, false acceptance rate (FAR) and false rejection rate (FRR). The ROC curve for the first experiment is shown in figure 6. It is a plot of FAR against FRR for a number of threshold values.

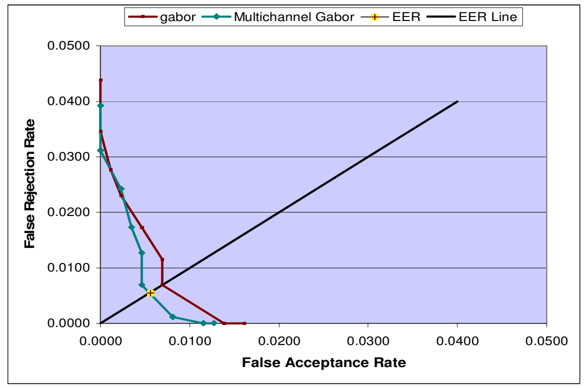

Figure 6. ROC curves for Experiment 1.

For this experiment, the minimum EER is achieved using multichannel gabor filter, which is equal to 0.0054. The minimum EER indicates a better technique.

B. *Experiment 2*

For the second experiment, the average image of first three images is computed and used while computing the recognition results [10]. And this average image along with the first three images of a class is considered as training images. The last four images of a class are treated as testing images. Table 2 shows the best results for experiment 2.

TABLE II.

RECOGNITION RESULTS FOR EXPERIMENT 2.

Case	Method	Number of Filters	Accuracy (%)	Threshold
I	Multichannel gabor	25	98.15	0.32
	gabor	30	98.66	0.30
II	Multichannel gabor	30	99.16	0.32
	gabor	30	98.82	0.33

The table shows the best results obtained for both techniques in experiment 2. Multichannel gabor filter provides the best result of 99.16% for 30 filters using enhanced images. Gabor filter gives an accuracy of 98.82% for 30 filters using enhanced images. It gives the better results than that obtained in the previous experiment. Figure 6 displays a graph of the best results for experiment 2.

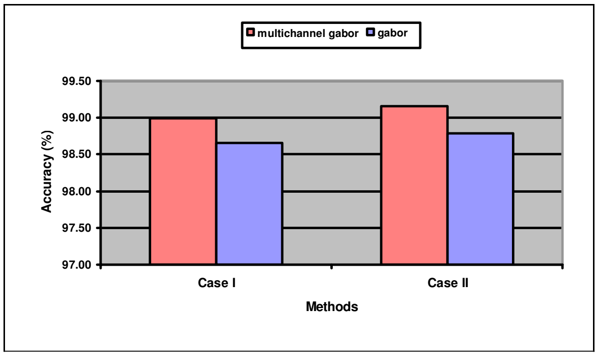

Figure 7. Best accuracy rates achieved in experiment 2.

For experiment 2, the ROC curve is shown in figure 8. The EER for multichannel gabor filter gives a minimum value equal to 0.0040. This ROC curve is giving the minimum EER than experiment 1.

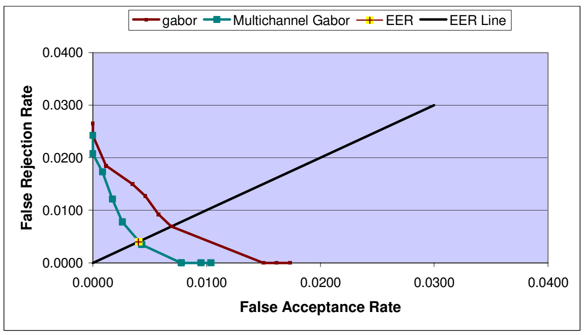

Figure 8. ROC curves for Experiment 2. Minimum EER is 0.0040.

The best accuracy achieved in this work is 99.16%. The hamming distance at this point is 0.32. The multichannel gabor filter gives best result in second experiment, where four training images are used. The images with complete background subtraction provide the high accuracy.

Since gabor filters are applied using filter banks containing different number of filters. After analyzing the results, it shows that using a bank of 30 gabor filters gives the best accuracy rates. The 30 filters are used in the experiments by varying the wavelengths and orientations of the filters. The wavelengths chosen are 3, 5, 7, 9, 11, 13 and orientation angles used are 0, 30, 60, 90, 120. Figure 9 shows a comparison of filter banks in terms of accuracy achieved for both types of gabor filters. It is clear from the figure that the multichannel gabor filter works better than the gabor filter applied at once on the entire image. It means that the local information extraction and combining it into global feature vectors is a better choice for accurate recognition results.

V. Conclusion

The iris feature extraction is the most important step of the entire recognition system. In this paper, two types of gabor filters are used to extract features from the CASIA version 1.0 iris database. A number of filter banks are experimented. The

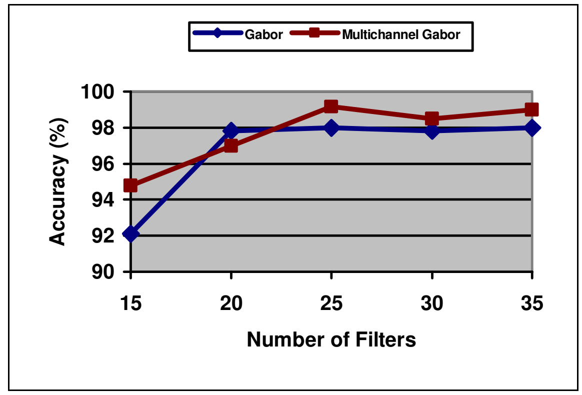

Figure 9. Number of Gabor filters Vs Best accuracy achieved in all experiments.

best result is achieved using multichannel gabor filter, that is 99.16%. And the best result is achieved using enhanced images after the complete background subtraction.

VI. References

[1] Basit, M. Y. Javed, and S. Masood, "Non-circular pupil localization in iris images," 4th International Conference on Emerging Technologies (IEEE ICET 2008), pp. 157-159, 2008.

[2] Xing Ming, Zhihui Li, Zhengxuan Wang, Xiaodong Zhu, "Multi-matching process based on wavelet transform for iris recognition," Proceedings of the Seventh IEEE Workshop on Applications of Computer Vision (WACV/MOTION'05), 2005.

[3] A. Basit and M. Y. Javed, "A fast and robust iris localization method," in IADIS International Conference on Applied Computing, pp. 557-560, 2006.

[4] Daugman JG., "High confidence visual recognition of persons by a test of statistical independence," IEEE Transaction on Pattern Analysis and Machine Intelligence, vol. 5, no. 11, pp. 1148-1161, 1993.

[5] Li Ma, Yunhong Wang, Tieniu Tan, "Iris recognition based on multichannel gabor filtering," ACCV2002: The 5th Asian Conference on Computer Vision, 23-25 January 2002, Melbourne, Australia, 2002.

[6] Li Ma, Tieniu Tan, Yunhong Wang, and Dexin Zhang, "Personal identification based on iris texture analysis," in IEEE Transactions on Pattern Analysis and Machine Intelligence, pp. 1519–1533, 2003.

[7] Li Ma, YunhongWang, and Tieniu Tan., "Iris recognition using circular symmetric filters," in Int. Conf. on Pattern Recognition, pp: 414–417, 2002.

[8] Basit and M. Javed, Y., "Localization of iris in gray scale images using intensity gradient," Optics and Lasers in Engineering, vol. 45, pp. 1107-1114, 2007.

[9] S. Lim, K. Lee, Byeon and T. Kim, "Efficient iris recognition through improvement of feature vector and classifier", ETRI Journal, Volume 23, Number 2, pp. 61-70, June 2001.

[10] S. Minhas, M.Y. Javed, and A. Basit, "Iris feature extraction using wavelet transform," Proceedings of the IASTED international conference on Signal and Image Processing (SIP 2009), pp. 198-203, 2009.