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Iris recognition robust to noises

Jaemin Kim, Jungwoo Won, and Seongwon Cho
School of Electronic and Electrical Engineering, Hongik University
72-1 Sangsu-dong Mapo-gu, Seoul, Korea
email: jaemin@hongik.ac.kr

***Abstract*—This paper describes a new iris recognition method using shift-invariant subbands. First, an iris image is preprocessed to compensate the variation of the iris image. Then, the preprocessed iris image is decomposed into multiple subbands using a shift-invariant wavelet transform. The best subband among them, which have rich information for various iris pattern and robust to noises, is selected for iris recognition. The quantized pixels of the best subband yield the feature representation. Experimentally, we show that the proposed method produced superb performance in iris recognition.**

Index Terms—Iris recognition, shift-invariant wavelet transform, normalized correlation coefficients.

I. INTRODUCTION

The human iris, visible through the clean cornea as the colored disc inside the eye, is a thin contractile diaphragm composed mostly of connective tissue and smooth muscle fibers. It is attached to the eye's ciliary body and open to the pupil. Human iris patterns are highly distinctive to an individual and the image of an eye can bc taken at a distance [1]. The automatic verification of an individual based on the human iris has developed in the last decade [2].

Various iris recognition methods have been proposed for automatic personal identification and verification. Daugman [3] first presented a prototype system for iris recognition. For the feature representation, it makes use of a decomposition derived from the application of a two-dimensional Gabor filter to the iris image pattern. It reported good performance on a diverse database. Wildes [2] presented another iris recognition system. It decomposes the iris pattern into the multiresolution pyramid layers using a wavelet transform. It reported as good performance as the system of Daugman. Both systems of Daugman and Wildes employ carefully designed image acquisition devices to get equal high quality iris images [2,4]. The devices minimize the deformation of the iris pattern and acquire the sharp and glare-free iris images under fixed illumination. However, these demands are not easily satisfied in many field applications.

Discrete wavelet transforms are sensitive to a small shift of a full-resolution iris image in the space domain [5,6,7]. Mallat [6] built a translation-invariant representation from zero-crossings of the full-density wavelet subbands. Roche et al. [4] decompose one-dimensional intensity signals computed on circles in the iris and use zero-crossings of the decomposed signals for the feature representation. The spurious zero-crossing points can degrade the performance.

A cheap image acquisition system using a fixed focus camera has difficulty in capturing equal high quality iris images. This requires new iris recognition methods robust to noises. Once the iris image in the polar coordinate plane is transformed to the normalized image in the rectangular coordinate plane, the characteristics of the normalized iris image can be efficiently represented by the horizontal and vertical wavelet components. Some wavelet components have rich information to classify various iris patterns and be insensitive to various noises: sensor noise, iris localization error, different image contrast, the iris texture deformation due to a small amount of movement of the dilator and sphincter muscles etc. This paper describes a new feature representation method based on these components.

This paper is organized as follows: Section II briefly addresses the preprocessing. Section III describes a new feature representation method for the iris recognition. Section IV addresses the similarity measure and the verification method used for the comparison of performance different iris recognition methods. Section V shows the experimental results. Finally, we conclude in Section VI with a summary of the proposed method.

II. PREPROCESSING

Iris recognition methods require accurate iris localization for successful processing because the iris is a small part of an acquired image. The visual surface of the iris lies outside the pupil and inside the limbus, the border between the sclera and the iris. The iris localization is shown in Fig. 1. The localized iris images are enhanced using histogram equalization because the acquired iris images have different contrast. The variation of the illumination causes the iris to shrink or to expand. For the iris recognition, it is necessary to compensate the variation of the iris size in the radius direction. A common method is to map the disk-shaped iris to a rectangle block of a fixed size [2]. A normalized iris image is shown in Fig. 2.

III. FEATURE EXTRACTION

In this section, we describe a new feature representation method using a shift-invariant wavelet transform.

A. Subband Decomposition

For the feature extraction, we first decomposed the normalized iris image into sixteen subbands using cascading horizontal and vertical two-band filter banks. Fig. 3 shows the decomposition of the full band image into sixteen subbands. After subband decomposition, we choose the best subband among them that has rich information to classify various iris patterns and is insensitive to various noises. Each pixel element of a subband is quantized to reduce the size of the feature vector.

B. Shift-invariant Decomposition

The location and strength of an edge in a subband image are sensitive to a small shift of the full-resolution band because of the aliasing noise. The shift-sensitive problem is reported in many papers on wavelet transform, and various solutions are proposed [5,6,7]. As the M-band method of Liang et al. [5], we accomplish the subband decomposition over all possible space-shifts. Due to the shift of the full band image, a subband, f_{HLLL}, has sixteen different forms: $f^{i,j}_{HLLL}, i, j = 0,1,2,3$, which is shown in Fig. 4. Due to the accurate iris localization and the normalization, we can consider only a small amount of space shifts.

IV. Similarity Measure and Verification

For the iris classification and verification, we use the best subband, f_{HLLL}, that has rich information to classify various iris patterns and be insensitive to various noises. The similarity measure for feature classification is the normalized correlation between the acquired and data base representations.

V. Experimental results

The iris database used in the experiments consists of 150 different human eyes and, 10 photos per each eye. The photographs were taken in different conditions.

The comparison of different methods is based on the FAR (False Accept Rate) and FRR (False Reject Rate) of the iris verification. We carry out all possible 2,250,000 comparisons between different pairs of irises in the database.

First, we compared the performance of two different methods: shift-invariant and shift-variant subband decompositions. Fig.5 (a) and (b) show the verification performance of two methods. The shift-invariant method yields ten times better accuracy than the shift-variant method.

Second, we checked how much two-bit quantization of each pixel degrades the verification performance. Fig. 5 (a) and (b) show that two-bit quantization does not degrade the verification performance much.

Finally, we compared the proposed iris recognition method with the pyramid decomposition method of Wildes [2]. Table 1 shows the performance of two methods. The experimental results show that the proposed method produced superb performance in iris recognition.

VI. Conclusion

This paper has described a new iris recognition method using shift-invariant subbands. First, the localized iris image is enhanced and normalized to compensate the variation of the iris image. Then, the preprocessed iris image is decomposed into sixteen subbands using shift-invariant wavelet transform. The best subband among them, which have rich information for various iris pattern and robust to noises, is selected for iris recognition. The quantized pixels of the best subband yield the final feature representation. Experimentally, we showed that the proposed method produced superb performance in iris recognition.

References

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Method	FAR	FRR
Pyramid decomposition method	**0.41%**	**0.17%**
The Proposed method	**0.02%**	**0.08%**

Table. 1. Verification performances of two methods.

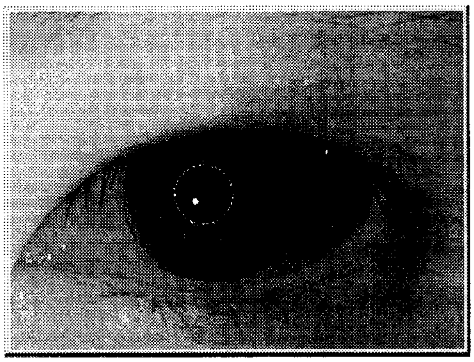

Fig. 1 Localized iris image.

Fig. 2. Normalized iris image.

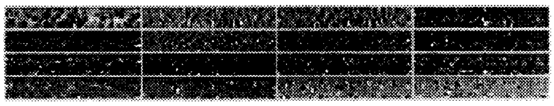

Fig. 3. 16 subbands.

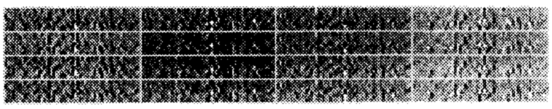

Fig. 4. 16 different form of a subband, $f^{i,j}_{HLLL}$, $i, j = 0,1,2,3$.

FAR = 0.69% FRR = 0.40% TOT = 1.19%	FAR = 1.07% FRR = 0.12% TOT = 1.19%	FAR = 0.91% FRR = 0.13% TOT = 1.04%	FAR = 5.69% FRR = 1.01% TOT = 6.70%
FAR = 2.02% FRR = 0.50% TOT = 2.52%	FAR = 2.64% FRR = 0.79% TOT = 3.43%	FAR = 1.85% FRR = 0.34% TOT = 2.19%	FAR = 8.67% FRR = 1.12% TOT = 9.79%
FAR = 0.96% FRR = 0.47% TOT = 1.43%	FAR = 2.02% FRR = 0.34% TOT = 2.36%	FAR = 1.89% FRR = 0.31% TOT = 2.20%	FAR = 9.64% FRR = 1.15% TOT = 10.79%
FAR = 1.53% FRR = 0.45% TOT = 1.98%	FAR = 6.19% FRR = 1.06% TOT = 7.25%	FAR = 7.97% FRR = 0.64% TOT = 8.61%	FAR = 23.59% FRR = 4.02% TOT = 27.61%

(a)

FAR = 0.69% FRR = 0.27% TOT = 0.96%	FAR = 0.07% FRR = 0.06% TOT = 0.13%	FAR = 0.02% FRR = 0.08% TOT = 0.10%	FAR = 1.00% FRR = 0.24% TOT = 1.24%
FAR = 0.77% FRR = 0.51% TOT = 1.27%	FAR = 0.53% FRR = 0.15% TOT = 0.67%	FAR = 0.27% FRR = 0.13% TOT = 0.40%	FAR = 2.31% FRR = 0.62% TOT = 2.92%
FAR = 0.60% FRR = 0.49% TOT = 1.09%	FAR = 0.42% FRR = 0.08% TOT = 0.50%	FAR = 0.31% FRR = 0.15% TOT = 0.45%	FAR = 2.59% FRR = 1.16% TOT = 3.75%
FAR = 0.41% FRR = 0.22% TOT = 0.635	FAR = 1.82% FRR = 0.72% TOT = 2.54%	FAR = 2.40% FRR = 1.06% TOT = 3.46%	FAR = 12.79% FRR = 5.75% TOT = 18.55%

(b)

FAR = 0.75% FRR = 0.20% TOT = 0.94%	FAR = 0.03% FRR = 0.03% TOT = 0.05%	FAR = 0.02% FRR = 0.01% TOT = 0.03%	FAR = 0.65% FRR = 0.21% TOT = 0.86%
FAR = 1.37% FRR = 0.84% TOT = 2.20%	FAR = 0.37% FRR = 0.23% TOT = 0.61%	FAR = 0.30% FRR = 0.075 TOT = 0.37%	FAR = 1.59% FRR = 0.44% TOT = 2.04%
FAR = 0.52% FRR = 0.45% TOT = 0.97%	FAR = 0.21% FRR = 0.14% TOT = 0.34%	FAR = 0.29% FRR = 0.07% TOT = 0.36%	FAR = 2.01% FRR = 0.70% TOT = 2.71%
FAR = 0.75% FRR = 0.47% TOT = 1.22%	FAR = 1.73% FRR = 0.48% TOT = 2.20%	FAR = 2.19% FRR = 0.75% TOT = 2.93%	FAR = 9.51% FRR = 5.73% TOT = 15.24%

(c)

Fig. 5. FAR and FRR of iris verification based on one subband: (a) with 2-bit quantized pixels and shift-variant method, (b) with 2-bit quantized pixels and shift-invariant, (c) with floating point pixels and shift-invariant method.