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Iris Feature Extraction using Local Thresholding with Variable Block Size

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Abstract: This paper presents a novel approach that uses local thresholding with an optimal block size to extract the features of the space domain from an image of the iris. The block size is selected optimally from two kinds, based on the variance of pixel intensity in the block of interest.

The results of several experiments show that a complete separation of the matching intra-class and inter-class score distribution can be achieved. Furthermore, the equal error rate and false rejection rate achieved by using the proposed approach are 0.02% and 0.32%, respectively, thereby improving those obtained with the conventional approach, i.e., 0.89% and 24%, respectively.

1. Introduction

The term biometric refers to a person's behavioral or physiological characteristics. Physiological biometric characteristics are associated with body parts, which are generally stable, whereas behavioral biometrics is related to the behavior of the person, which is comparatively less stable. Compared to knowledge or token-based approaches, biometric systems are more advantageous to authenticate a person's identity. The iris is one of the most useful biometric traits for person identification [1] due to its high stability and inalterability. The human iris comprises the annular region between the pupil and the sclera region of the eyeball. This area has a complex yet regular structure that provides abundant visible textural information. The texture of the iris is unique for each individual [2]. Generally, pre-processing, normalization, feature extraction, and matching are some basic steps of iris recognition systems. However, the generation of feature vectors from iris images and then matching these with the prototype based on some distance metric form the major task.

The extraction of features from the iris is one of the most important processes in the authentication. As the iris contains many fine and multi-value patterns, it is difficult to extract iris features by using simple noise reduction and thresholding.

Previous studies [3-4] proposed a gray-scale morphological operation to extract fine and multi-value patterns as multi-value skeletons. However, the precise extraction of low-contrast patterns was not achieved, because these approaches applied a fixed value for the threshold. Moreover, the loss of information relating to the pattern widths during the extraction of skeleton patterns became problematic.

This paper presents a novel iris feature extraction method using local thresholding with variable block sizing to detect fine and low-contrast patterns from iris images. The proposed approach is carried out using local thresholding, which is one of the threshold operations in which the threshold value is determined as the average intensity of the block with the center being the pixel of interest. The block size for thresholding is automatically determined based on the variance of intensity in the specified block.

2. Local thresholding with variable block size

2. 1 Related work

Iris recognition is one of the most reliable biometric verification technologies. Iris feature extraction is a key issue in iris recognition. The "gray-scale morphological skeleton method" is a novel approach to extract the space domain features from the iris image, which requires gray-scale morphological filtering [3]. It is well known that the skeleton which shows the features of images is extracted from binary images by using morphological filtering. Therefore, to extract the features of the iris, this approach applies the gray-scale morphological filtering to the iris image and obtains its skeleton. The binary skeleton, which is regarded as the iris code, is obtained by threshold processing. The Hamming distance was employed for the classification of iris codes. In the proposed method, the Hamming distance of intro class and inter class are separated completely.

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2. 2 Principle of proposed approach

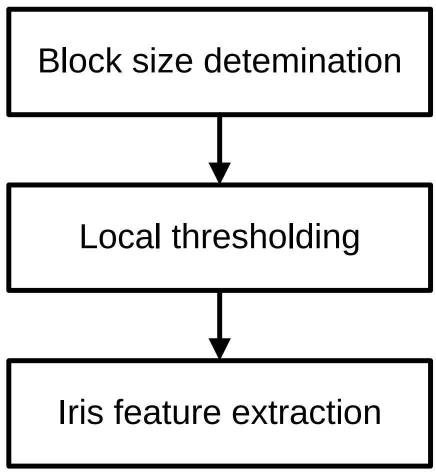
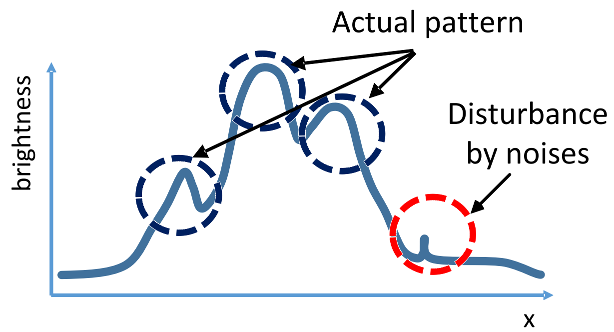
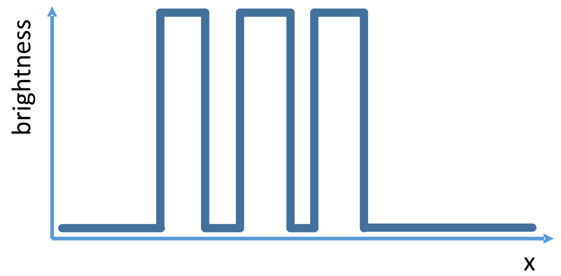


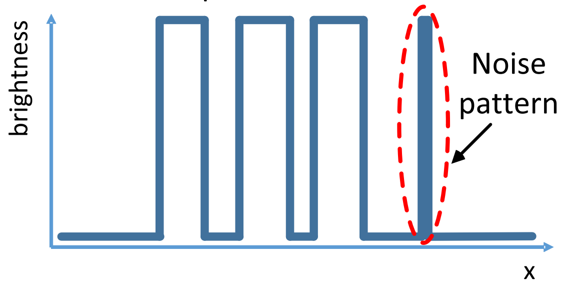
Figure 1. Overview of proposed approach.



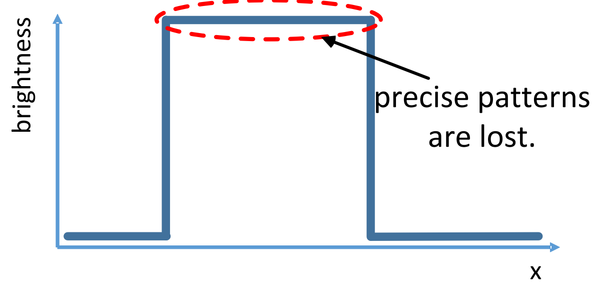
(a) Grayscale profile along the specified horizontal line in iris image.



(b) The local thresholding result of (a) with optimal size of block.



(c) The local thresholding result of (a) with size too small block.



(d) The local thresholding result of (a) with size too large block.

Figure 2. Principle of local thresholding.

The proposed approach "Local thresholding with variable block size" consists of the two steps, i.e., "Block size determination" and "Local thresholding", as shown in Figure 1. To obtain iris features from the binary image, the first and perhaps most critical step is to convert the initial gray-scale image of iris, in most cases, by performing some form of thresholding operation.

In general, the iris region contains several types of patterns whose sizes and brightness vary widely. It is imperative to find the optimal threshold value for the extraction of iris features. The proposed approach applies the local thresholding with the optimal block size selection to extract almost all iris features.

Figure 2 illustrates the concept of local thresholding. The basic idea of the local thresholding is the point operation, which is the conversion of the gray-scale brightness of the pixel of interest into the logical value "high" when the brightness is greater than the threshold value; in the case when the brightness is lower than the threshold value, the grayscale brightness is converted into the logical value "low" [7-8]. In general, in the standard local thresholding, the threshold value is determined as the averaged value of the specified size block around the pixel of interest.

Figure 2 also shows the concept of local thresholding along the specified line in the iris image. It includes several actual patterns, which are iris features, and disturbed noise patterns. The thresholding operation successfully extracts the iris features when the optimal block size is applied for local thresholding, as shown in Figure 2 (a). However, when the block size is too small, a small noise pattern is extracted as the iris pattern, as shown Figure 2 (c). Therefore, the possibility of false extractions of iris patterns exists. Likewise, when the block size is too large for local thresholding, it eliminates the precise pattern of iris region in each block, as shown in Figure 2 (d).

2. 3 Block size determination

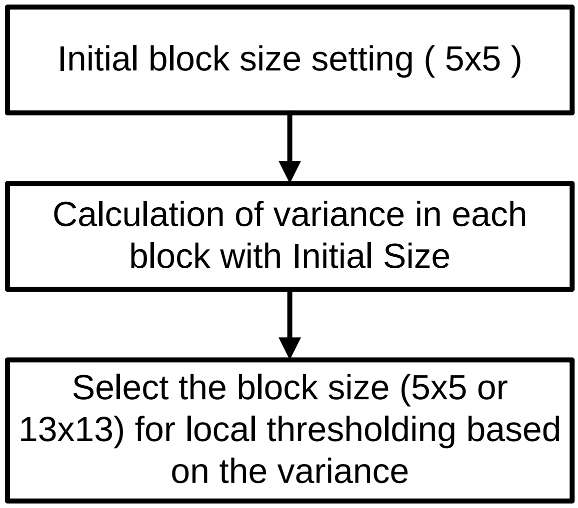


Figure 3. Overview of block size determination.

The overview of the block size determination is shown in Figure 3. In the proposed approach, the size of the block, which is used for local thresholding, is determined optimally for reliable and precise iris pattern extraction, based on the variance of intensity inside the block of interest. The initial block size is given by manually based on the human knowledge. It should be optimize for each environment of iris acquisition to set the initial block size. In this case, the size 5x5 is determined as the initial block size. The proposed method optimally selects one of two specified block sizes (5x5 or 13x13), which are prepared block size for local thresholding. When the block contains several smaller and detail pattern, the variance of the brightness in the block becomes larger. In this case, it needs to select smaller size of the block for local thresholding. On the other hand, when the block contains several larger pattern, the variance of the brightness in the block becomes smaller. In this case, it needs to select larger size of the block for local thresholding.

The initial block size 5x5 is selected when the variance of the brightness in the block is smaller than the criteria of the variance, which is given manually. Otherwise, the block size 13x13 is determined as the optimal block size for the local thresholding.

2. 4 Local thresholding

Figure 4 shows the overview of the local thresholding. The threshold value for local thresholding is determined as the average value of the pixel intensity of the block of interest. As mentioned before, the basic idea of the local thresholding is the point operation, which is the conversion of the gray-scale brightness of the pixel of interest into the logical values “high” and “low” when the brightness is greater and lesser than the threshold value, respectively. In general, in the standard local thresholding, the threshold value is determined as the averaged value of the specified size block around the pixel of interest.

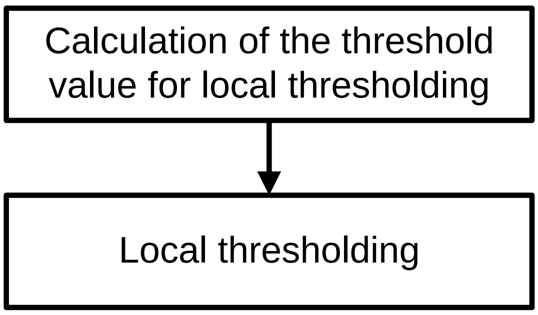


Figure 4. Overview of Local thresholding.

2. 5 Iris feature extraction

Iris feature extraction is a key process where the two dimensional image is transfered to a set of numerical parameters. The iris contains unique features, such as stripes, freckles, coronas, etc. These features are collectively referred to as the texture of the iris. These features were extracted using following algorithms from the thresholding result.

Step 1 : Normalized polar converted iris image is the size of 360x80.

Step 2 : There are several obstacles on the iris region, such as eyerids, eyelashes and reflaction patterns. The part of the polar converted iris image is cut to size 120 (row) x 80 (col) in order to avoid obstacles on the iris region.

Step 3 : If the pixel is “white” in the thresholding result, make it’s value 1.

Step 4 : Else make it 0.

After the iris feature extraction, it is generated 2-dimensional template data, called “iris code”, for each iris feature. It can identify the person by evaluatation of Humming distance among “iris codes”.

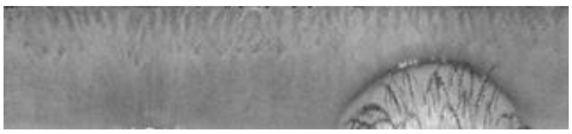
3. Experimental Results

An example of the proposed approach is shown in Figure 5. It is assumed that the detection of the center of the pupil, the extraction of the iris region, the polar conversion of the iris region, and the normalization of the iris polar image are carried by the conventional approach [5] before applying the proposed approach. An averaging filter is implemented to reduce image noise and the affection. The variance of pixel intensities is evaluated in the square block around the pixel of interest. In case the estimated variance is higher than the given threshold value, the block selected for variance evaluation is exchanged with a smaller one. Otherwise, the block is replaced with a larger one. After selection of the optical block size, local thresholding is carried out to extract the iris feature in the form of iris binary code.

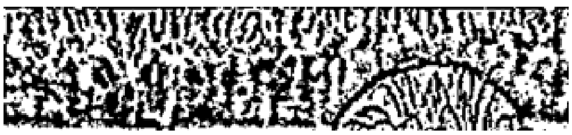
Several experiments were performed to evaluate the proposed approach. Data from 105 persons, including three images per one person, were selected from the iris image database CASIA ver. 1 [6], which is one of commonly used iris databases. Figure 5 (a) shows an example of experimental results obtained by the proposed approach. The images in Figure 5 (b) show that the low-contrast iris pattern is extracted precisely. The matching score is defined as the similarity between extracted iris feature codes. Figure 6 indicates the matching score distribution for both the intra class and inter class and shows that the proposed approach is capable of separating the intra-class and inter-class distribution completely.

The experimental results of false rejection rate (FRR) and false acceptance rate (FAR) by the proposed approach is shown in Figure 7, which is evaluated using CASIA Ver. 1 database. The equal error rate (EER) of the proposed approach are also evaluated using the CASIA Ver. 1 database, and the results are listed in Table 1 together with the results obtained using the conventional approach [3] for comparison purposes. The results in Table 1 show that both the EER and FRR of the proposed approach are much smaller than those of the conventional approach [3].

However, the computation time of the proposed approach is four times larger than that of the conventional approach.



(a) An example of polar converted iris image



(b) The thresholding result of example (a) by proposed approach.

Figure 5. Example result of iris feature extraction by proposed approach.

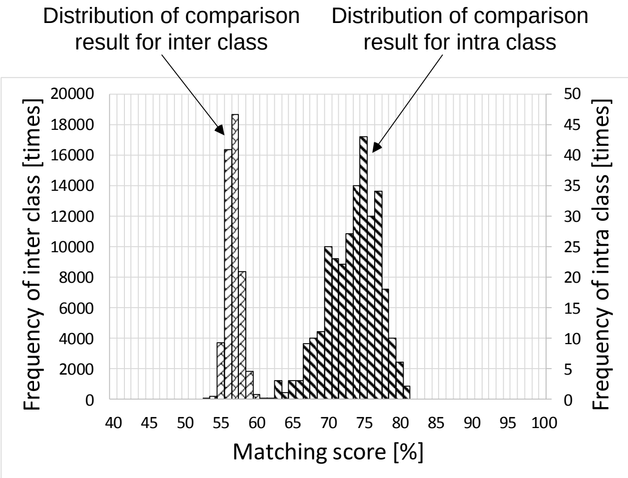


Figure 6. Matching score distribution of intra class and inter class by proposed approach.

Table 1. Comparison between proposed approach and conventional approach [3].

Methodologies	EER [%]	FRR [%]
Conventional [3]	0.89	24
Proposed	0.002	0.32

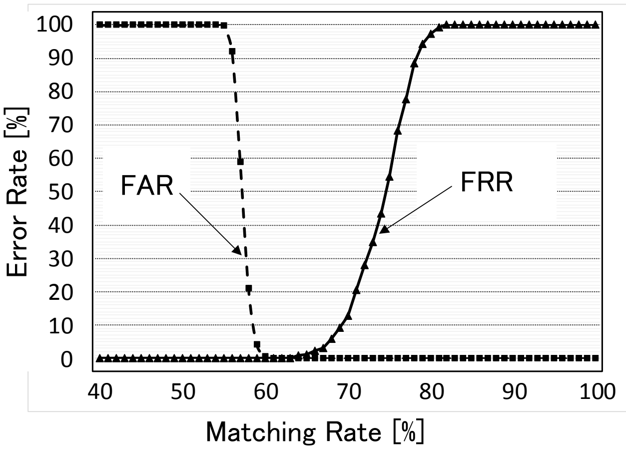


Figure 7. The results of FAR and FRR with respect to matching score distribution by proposed approach.

4. Conclusion

A novel approach to extract the features of the space domain from an iris image is proposed. The method uses local thresholding with an optimal block size. The block size is selected optimally from two kinds, based on the variance of the pixel intensity in the block of interest.

Several experimental results show that the matching intra-class and inter-class score distribution is separated completely. Furthermore, the proposed approach achieved an EER and FRR of 0.02% and 0.32%, respectively, compared to those of the conventional approach [3], i.e., 0.89% and 24%, respectively.

However, there still remains future work to reduce the computational time because the computation time of the proposed approach becomes 4 times larger than that of the conventional approach.

Acknowledgement

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