A New Shape-Based Iris Recognition

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ABSTRACT

This paper presents a new shape-based iris recognition method. The new method utilizes intensity patterns formed by physical iris structures such as crypts and naevi. These structures appear as regions with heavily dark pigmented blobs. We purpose a modified thresholding technique called quotient thresholding, The thresholding is used for analyzing and segmenting the iris features. Shape information of these segmented features is measured by fitting four different circles onto the segmented features. Our experiments indicate interesting and promising results.

Keywords: Iris Recognition, Iris Textures Analysis, Shape-based Iris recognition, Quotient Thresholding.

1. INTRODUCTION

1.1 Overview

Securely accessing information becomes key issue in many applications such as patient monitoring, accessing personal electronic devices, and electronic banking. These applications require high levels of security information protection. The old conventional protection methods such as using keys or passwords fall short for these applications. Biometrics have been introduced to provide better and higher security information protection. The biometric system is a system of identifying or verifying a person using his or her physiological or behavioral characteristics. Examples of biometrics are fingerprints, faces, speeches, DNAs and irises, etc.

In this paper, a system of iris recognition has been developed as the human iris provides high accurate and reliable features for personal authentication. The human iris is a protected organ composed of tissues and muscles. These tissues and muscles form both invisible and visible iris features. The visible features are pigment related features. Examples of these features are crypts, furrows, pigment frill, as shown in figure 1. Patterns of these physical iris features are unique and stable.

Most research in iris recognition, such as ones developed by Daugman [1] and Lima [2], analyzes and extracts iris features using frequency-spatial domain filters. Recently, there is some research on shape-base iris recognition. Sun [3] uses zero-crossings of wavelet transform to extract iris features. He represents the features using five geometric moments. Li Ma [4] uses Guassian-Hermite moments to reflect shape of iris textures. Our proposed approach is shape-based iris recognition. We reflect shape information of iris features by fitting circles onto the features. The iris features are extracted using a modified thresholding called quotient thresholding. In quotient thresholding, the threshold values for each image in the database are adaptive to illumination of the image.

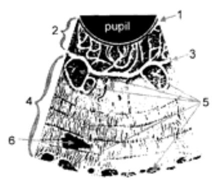


Fig.1: *The Iris Pigment Related features: 1-pigment frill, 2-pupillary area, 3-collarette, 4-ciliary area, 5-crypts, 6-pigment spot.*

1.2 Outline

The rest of this paper is organized as follows: section 2 describes our proposed iris recognition. Four main steps, which are preprocessing, feature extraction, feature encoding and matching are explained in details. Section 3 illustrates our experimental results and discussions. The last section, section 4 is our conclusion.

2. THE PROPOSED IRIS RECOGNITION

Our proposed iris recognition attempts to imitate the adaptability characteristic of the human eye in which an object is perceived similarly under wide range of illumination. Observing a black and white checker board in a bright lighting and dim room looks the same. We perceive object as if its color or intensity composition is maintained. With this concept, we developed a quotient thresholding operation. The thresholding aims to maintain ratio of foreground and background of images.

Our iris recognition approach is composed of four main steps, that are preprocessing, feature extraction, feature encoding, and matching. Details are described in the following sections.

2.1 Iris Preprocessing

Often, eye images obtained from the acquisition devices contain not only an iris, but also some irrelevant components such sclera, pupils, light reflections etc. Since an iris is sensitive to changes of illumination, the acquired images of the same iris usually have different sizes. To accomplish good iris recognition results, some preprocessing operations must be applied to an iris image.

Objectives of the preprocessing are: (1) localizing an iris given an eye image, (2) normalizing an iris into a pre-specified fixed size.

Iris localization is to locate the inner and outer boundaries of an iris. The inner boundary of an iris is a boundary separating the iris from the pupil, whereas the outer boundary is a boundary separating the iris from the sclera zone. Both boundaries can be located by exploiting intensity differences among organs (pupil, iris, and sclera) and a prior knowledge of circular-like shape of pupil and iris.

In our approach, a simple thresholding technique is used in detecting the pupil since its intensity range is different from the others. The edge detection is then applied to the segmented area. The edge information serves as data for circular model fitting. The fitting process results in two parameters: r-inner and center, which denote the inner boundary and the center of an iris, respectively. The obtained center position is used as reference point for the rest processes of our recognition.

The outer boundary of iris is located by searching for the first significant change of intensity summation along the specified arc. The outer boundary is modeled using a circle having a reference point as its center. More details of our iris localization can be found in [5].

After localizing an iris, the iris is normalized to the same fixed size. Linear interpolation is used in our scheme.

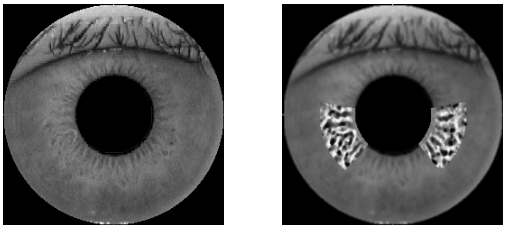
2.2 Iris Feature Extraction

We analyze iris features based on intensity variations of visible iris textures. The visible iris textures such as crypts, freckles, moles are typically appeared as regions with dark pigmented blobs. Obviously, these iris textures belong to regions of minimum of an iris image. Extracting these features implies to segmenting the regions of minimum. The simplest and popular technique for segmenting regions of minimum is thresholding.

The conventional thresholding technique partitions an image into regions of foreground and background by specifying a threshold value. Pixels whose intensity values are lower than the specified threshold value are assigned as background, otherwise as foreground. By fixing the threshold values, the conventional thresholding operation is sensitive to changes of image illumination. The thresholding yields different segmented regions even if slightly variations of illumination are present in images of an object (iris). However, we don't have this problem in our daily life. Our eye can adjust to amount of coming lights in order to retain the same level of color or intensity sensitivity. Our feature extraction approach attempts to imitate this human characteristic. We aim to remain the same level of foreground and background.

In our approach, iris features are extracted using quotient thresholding technique. Quotient thresholding partitions an image into foreground and background areas such that the ratio of foreground and background are maintained across the iris images.

Before quotient thresholding operation, iris features are enhanced in order to obtain good feature extraction results. A normalized iris image is enhanced by a 3x3 mean filter, followed by local histogram equalization. The local histogram equalization serves two main proposes: (1) to improve an image contrast, (2) to reduce impacts of uneven illumination. Figure 2a shows a normalized iris image. Figure 2b shows its corresponding image after performing local histogram equalization. In our experiment, the enhancement operations are applied only to portions of an image in order to avoid problems caused from occlusions. The working areas are depicted in figure 2b. Since the local histogram equalization introduces some salt and pepper noises, a median filter is applied to the image. Our last step in feature extraction is quotient thresholding. We threshold images to maintain a quotient of 3/7 as shown in figure 3. Figure 4 shows results of thresholding two images of the same iris.



(a) (b)

Fig.2: *(a) A normalized iris image. (b) The corresponding iris image after performing local histogram equalization.*

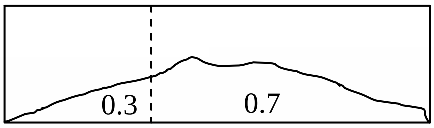
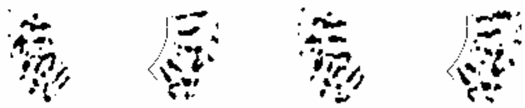


Fig.3: *An example of selected threshold value.*



(a) (b)

Fig.4: *Two images of extracted regions of an iris using a quotient of 3/7.*

2.3 Iris Feature Encoding

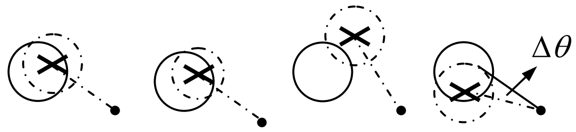
We reflect shape information of the extracted regions by fitting four different sizes of circle onto the regions. Circles with 9, 11, 13, and 15 pixels diameter are slide over the segmented regions. If any circle intersects with the extracted regions, its position (center position) and diameter are kept as our feature values. Using circles' position and diameter allows rotation invariant feature matching. Its detail is described in the next section.

2.4 Iris Matching

The obtained feature vector of an input image is compared to feature vectors of images in the database. Our matching score is a summation of diameter values of matched circles between the input and the references.

Two circles are considered to be matched if they satisfy two conditions: (1) Both circles have the same diameter value, (2) The position of the input circle falls inside the reference circle.

Figure 5 depicts possible cases in our matching. Two circles in figure 5a satisfy both matching conditions. They are matched. Figure 5b and 5c indicate the non-match cases, where figure 5b violates the first condition. Figure 5c violates the second condition. Figure 5d illustrates how the feature values tolerate to rotations.



(a) *(b)* *(c)* *(d)*

Fig.5: *(a) Match case (b) Non-match as having different diameters. (c) Non-match as the position lies outside the circle. (d) Match case with rotation of* $\Delta\theta$.

3. EXPERIMENTAL RESULTS

We validated our proposed iris recognition scheme using the CASIA iris database [6]. The database consists of 107 different irises. Each iris has 7 gray scale images. The recognition system is implemented on PC Pentium IV 2.4 GHz with 512 MB memory. Table 1 shows computational time of our recognition scheme.

Process	Computational Time(ms)
Preprocessing	410
Feature Extraction	250
Feature Encoding	111
Feature Matching	10

Table 1: *Computational time of our proposed iris recognition.*

From our experiments, quotient thresholding is efficient in adapting to changes of illuminations across images. Figure 6a and 6b indicate how the extracted features of the same iris captured under two different lightings are similar. However, figure 6b is a counter clockwise rotated version of figure 6a. Figure 6c and 6d depicts the extracted regions obtained from other two irises. It is readily seen how differences the extracted features are.

Our system performance is evaluated using Leave-Two-Out method. Two out of seven images are randomly selected as test images. The ROC curve of our system is shown in figure 8. The area under the ROC curve is 0.957. In term of equal-error-rate, our system gives 9.081% EER. The correct recognition rate of our system is 90.92%. A summation of our overall system performance is indicated in table 2.

Even thought, our feature extraction method gives very promising iris features, the system performance is still below the performance of existing iris recognition systems [1, 2]. The major degradations are: (1) errors caused from occlusions, which are eyelashes, (2) errors caused from image translation and rotation, and (3) errors caused from not enough shape resolution in representing iris features.

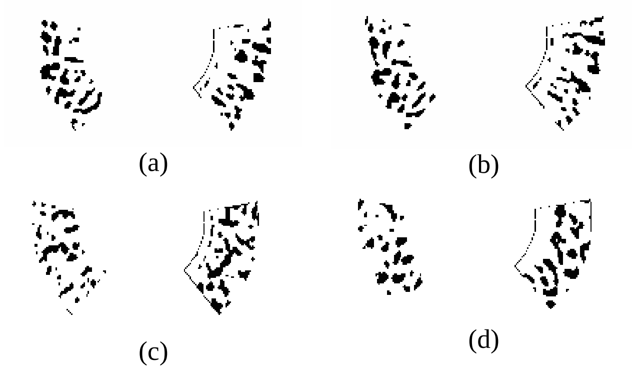


Fig.6: *The extracted features of three different irises. (a) and (b) are results obtained from the same iris. (c) and (d) are results obtained from the other two irises.*

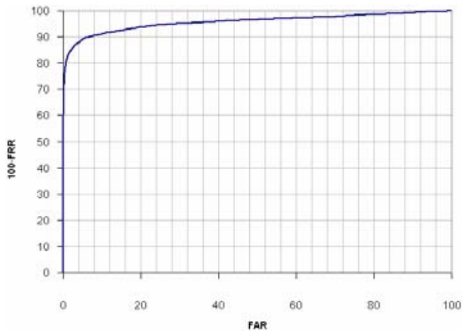


Fig.7: *The ROC curve of our system*

Type of Evaluation	%
Correct recognition rate (%)	90.92
Az (Area under the ROC Curve)	0.957
EER (%)	9.081

Table.2: *Our system performance*

3.1 Eyelashes Noise

Since our system relied on thresholding operation, distribution of an image is a key factor. Including eyelashes in an iris image significantly changes the distribution of the image. By fixing the ratio of the foreground and background, the extracted regions can be very different, as depicted in figure 8. Figure 8a and 8b are two images of the same iris. The eyelashes cover more iris textures in figure 8b. Its corresponding results obtained from local histogram are shown in figure 8c, and 8d, respectively. Its corresponding extracted features are shown in figure 8e and 8f, respectively. There are significant differences between the two extracted features even thought they are the features of the same iris.

3.2 Rotation and Translation

From the experiments, errors of our recognition system are also caused from image transformations:

rotation and translation. Even thought our approach is designed to handle rotation variance between images, our rotation limitation is less than 10 degrees. In the database, images of the same iris are rotated more than 10 degrees.

Another problem is caused by miss localizing an iris. Miss localization results in having a wrong reference point and/or wrong inner and outer boundary. Thus, iris features are inappropriately normalized. Additionally, position feature values are deviated from their actual positions.

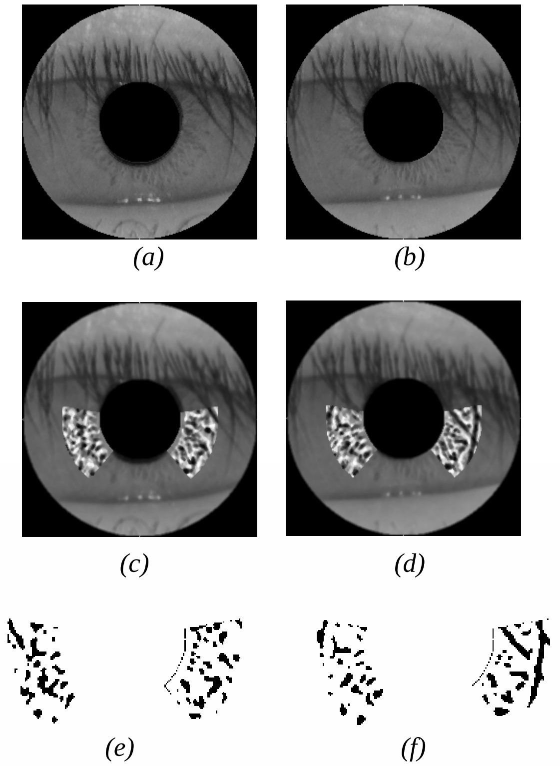


Fig.8: *An example of error caused from eyelashes (a) and (b) are images of the same iris, (c) and (d) are the corresponding results after performing local histogram equalization, (e) and (f) are the corresponding extracted features using quotient thresholding.*

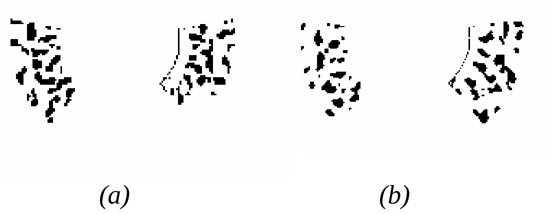


Fig.9: *An example of a false accept error in our system.*

3.3 Low Resolution of Shape Representation

Our experiment results indicate in insufficient feature representation, as shown in figure 9. The extracted regions of figure 9a and 9b are obtained from different irises. However, our recognition scheme reported the match for these two images. The extracted regions of both images are perceptually different, but the matching score of the two images are high. This implies a high probability of intersections between circles of the input features and the references. Representing the features with more different sizes of circles can be used to improve the recognition performance.

4. CONCLUSION AND FUTURE WORKS

In this paper, we have presented a new shape-based iris recognition scheme. The scheme introduces a new feature extraction algorithm. Iris features are extracted using a modified thresholding operation called quotient thresholding. Quotient thresholding partitions an image into regions of foreground and background such that its quotient is remained across images in the database. Our experiment results have shown an interesting and promising extracted iris features. These extracted features are worth of further research. Directions toward improving our iris recognition system are on developing better iris features representation and matching methods and on removing occlusions.

5. ACKNOWLEDGEMENT

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