Personal Identification Using Iris Recognition

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Abstract. In this paper, we propose a probable solution to implement a security system using an iris recognition technique. The implemented system acquires images with an infrared camera. It extracts a 2D code through scale-space filtering and concavity. Experiments are then performed using a set of 272 iris images taken from 18 persons. The results show that the iris feature patterns obtained can be clearly discriminated from person to person.

Keywords: iris, human identification, biometrics, scale-space filtering.

1 Introduction

Biometric identification systems, which rely on physical and structural features of the human body to identify a human-being, are used in various areas that require a high degree of security due to the superiority of its reliability and stability. Among these various methods, iris recognition is regarded as being the most distinct, consistent, and stable option. The appearance of an iris pattern is highly randomized with extremely data-rich physical structures that differ from person to person, even between monocular twins.

A viable iris identification system was first introduced in 1993 and a US patent soon followed. According to the patent, extracting 128 features of the iris and placing them in a 256-byte code has theoretically reduced identification errors to 1 in 800,000,000[1,2]. Several other methods were developed using isotropic bandpass decomposition and multi-channel Gabor filtering. A scale-space filtering approach [3] was introduced and proven to work efficiently with a high degree of reliability and confidence. In this paper, we introduce a probable solution to implement an iris recognition system using a scale-space filtering technique [3,4,5].

2 Iris Identification Algorithm

2.1 Segmentation

To identify the iris correctly in a given image, its inner and outer boundaries need to be located. To define the inner boundary, the center of the pupil is determined by examining its radius. The image value changes across the pupil's outer border with the iris. The outer boundary can be located similarly. Most methods use a geometric approach for boundary detection. Since the pupil is very simple in shape, the efficiency of the algorithm depends on computational speed rather than accuracy.

In this paper, the region corresponding to the pupil is first segmented as in earlier works[3,4] using brightness thresholding. Figure 1 shows an example of a transformed polar coordinate iris image.

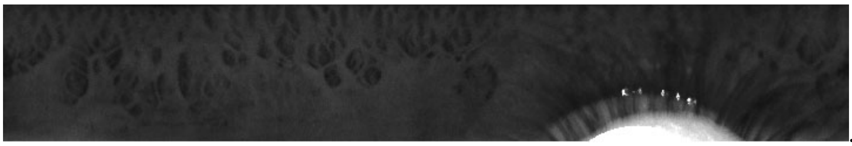

Fig. 1. Iris Image in a Polar Coordinate System

2 2. Extraction of Binary Iris Codes

In this work, variations in the directional properties of image brightness are used to describe iris features. A derivative of the grey level is investigated to determine whether the rate of grey level change is continuously increasing (concave-down) or decreasing (concave-up). Only the direction of concavity, not the magnitude, is considered. A value of 1 is assigned to a pixel with positive second derivatives while 0 is given to negative second derivatives. This method has the advantage of dealing with various eye colors or brightness factors pliably.

Since the derivatives are very noise-sensitive, it is difficult to extract iris features consistently. In order to fully conserve the original information while minimizing the effect of noise, a scale-space filtering technique is applied as introduced previously in [3]. Figure 2 shows an example of an extracted feature when applying scale-space filtering on the polar coordinates of an iris image when $\sigma= 4.5$.

Fig. 2. Iris Image in a Polar Coordinate System

A 2 dimensional iris code can be obtained by subsampling the extracted feature. The sampling interval is determined by the size of the desired codes. For personal identification, two iris codes are XOR-ed to each other and the degree of mismatch is then measured. The norms of the resultant XOR-ed bit patterns and AND-ed mask vectors are obtained in order to compute a fractional Hamming Distance, HD. The Hamming Distance is a similarity measure and represents the fraction of bits that disagree between two given codes

3 Implementation of the iris recognition system

The proposed iris recognition system can be implemented cost effectively using ordinary equipment easily encountered in everyday life. A low-priced standard 640X480 USB Camera is chosen to interface with a Window based computer system through a USB port commonplace with most computers. A D2 web-camera from Alphacam is used. To obtain a clear iris image at a 20~30 cm distance, a 1/3” 9.8° 35mm lens is selected following an operational test.

White light, which is frequently used in recognition systems for lighting, was deemed to be unsuitable for our purpose due to its level of brightness. To acquire a clear iris image, the eye must be illuminated directly. A glaring light source generally makes people feel uncomfortable. Moreover, the reflection of a bright light source off the iris acts as noise and causes problems during the recognition process. Instead, a near-infrared LED is selected to minimize light reflection and user repulsion. Experiments were performed to identify the appropriate LED infrared-wavelength able to conserve meaningful iris features or patterns, while minimizing the effect of reflection. When a 700 nm wavelength (close to a visible ray) LED is used, details of the iris pattern can be conserved; however, the noise can not be effectively reduced. Likewise, with a wavelength of 940 nm, the border between the iris and the sclera is not clearly visible, making it difficult to extract an iris image. To minimize reflection, 4 less dazzling LEDs instead of 1 high powered LED are used for illumination. After careful consideration, an infrared LED wavelength of 850 nm is adopted as a light source with an IR bandpass filter for illumination.

4 Recognition Performance

Experiments were performed on a photographic database of eye images to analyze the recognition performance of the proposed approach. An ordinary Window-based computer was used for the simulation. 1,000 sheets of 640x480 gray scale images were acquired from 50 different pairs of human eyes using our prototype.

From the code image, 16 different sizes of two-dimensional binary iris code were extracted for analysis. The iris codes were XOR-ed to each other to compare their degree of similarity (or mismatch). Any region assumed to be contaminated was excluded as noted in Eq. 2. For the analysis, 49,500 code pairs from different people were randomly selected and XORed to retrieve the Hamming distance (HD).

Table 1 shows the results of each code according to variations in size. These results show that the proposed approach is highly effective. For example, as noted in Table 1, if the threshold is set for 0.62 with a 128X16 code, a person can be identified at FAR 0.2232X10-15 and FRR 0.0542. This means the chance of misidentification is limited to 2.2 cases per 1016 attempts. This is an appropriate level considering that the world’s population is roughly 7 billion. In addition, an FRR value of 0.0542 means that approximately one in 20 persons might be falsely rejected as an imposter. Subsequently, reexamination would be required. It should be noted as well that during about 50,000 experimental trials conducted using 128x16 bit code, not one single false acceptance occurred.

Table 1. FAR & FRR with Different Code Sizes

Code Size (bits)	Threshold (%)	FAR	**FRR**	Code Size (bits)	Threshold (%)	FAR	FRR
64*8	71	0.6159E-15	0.3644	256*8	69	0.2146E-15	0.3013
64*16	64	0.1675E-15	0.1402	256*16	65	0.343E-16	0.1567
64*32	63	0.1820E-15	0.1227	256*32	64	0.9361E-15	0.1293
64*64	63	0.4874E-15	0.1082	256*64	65	0.1587E-16	0.1447
128*8	66	0.2881E-16	0.1520	512*8	69	0.2331E-15	0.3184
128*16	62	0.2232E-15	0.0542	512*16	65	0.1202E-15	0.1769
128*32	62	0.2531E-15	0.0555	512*32	64	0.2331E-15	0.1502
128*64	61	0.4140E-15	0.0391	512*64	65	0.3715E-16	0.1616

5 Conclusion

Advances in hardware and software have made it possible to implement highly reliable compact personal identification systems using the iris of the human eye. The iris has more discriminators than any other biometric feature including the commonly used finger print. In addition, the image structure of the iris remains stable throughout a person's lifetime and can be acquired without any contact. In this paper, an implementation scheme is introduced which emphasizes the importance of not only performance but also implementation cost. The proposed method can be applied easily to ordinary articles in daily use, such as safety latches and automobile starting devices.

References

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