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Some Refinement on Iris Localization Algorithm

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ABSTRACT

Biometrics recognition is a common and reliable way to authenticate the identity of a living person based on physiological or behavioral characteristics. Iris recognition is one of the newer biometric recognition technologies used for personal identification. It is reliable and widely used. In general a typical iris recognition system consists of three basic module which include image acquisition, Iris Localization & pre-processing, Iris texture extraction & signature encoding and lastly Iris signature matching for recognition or verification.

One of the most important steps in iris recognition systems is iris localization, which is related to the detection of the exact location and contour of the iris in an image. (i.e it defines the inner and outer boundaries of iris region) Obviously, the performance of the identification system is closely related to the precision of the iris localization step. In this study, an efficient algorithm for iris localization is proposed. The algorithm proposed can accurately define both the inner and outer boundaries of the iris irrespective of the geometry it may be (circle or eclipse) by capturing the parameters that represents the geometry.

Keywords: *Biometrics, Iris recognition, Iris localization, Geometry, Inner and Outer boundaries*

1. INTRODUCTION

In the last decade computer based systems have become very essential part of our daily life [9]. We store private information that must be secure in sense of personal or corporate cases. Since there are billions of interconnected computers world-wide, security becomes a critical problem that must be addressed by continuous new reliable and robust identification, verification or cryptographic techniques involving user – based characteristics.

Reliable automatic recognition of individuals has long been an important goal, and it has taken on new importance in recent years. Using traditional password (PIN) Personal Identification Number) or user-id systems are not secure enough to provide full access control to a system [9]. In order to improve the security of such systems biometric information could be incorporated into the system. The use of biometric signatures, instead of tokens such as identification cards or computer passwords, continues to gain increasing attention as a means of identification and verification of individuals for controlling access to secured areas, materials, or systems [3]. A wide variety of biometrics has been considered over the years in support of these challenges. Today, biometric recognition is a common and reliable way to authenticate the identity of a living person based on physiological or behavioral characteristics.

A physiological characteristic is relatively stable physical characteristics, such as fingerprint, iris pattern, facial feature, hand geometry, DNA etc. This kind of measurement is basically unchanging and unalterable without significant duress [11]. A behavioral characteristic is more of a reflection of an individual’s psychological makeup as signature, speech pattern, or how one types at a keyboard. The degree of intra-personal variation in a physical characteristic is smaller than a behavioral characteristic. For examples, a signature is influenced by both controllable actions and less psychological factors, and speech pattern is influenced by current emotional state, whereas fingerprint template is independent [11]. Nevertheless all physiology-based biometrics don’t offer satisfactory recognition rates (False Acceptance and/or False Reject Rates, respectively referenced as FAR and FRR).

The automated personal identity authentication systems based on iris recognition are reputed to be the most reliable among all biometric methods [11]. The use of iris recognition for identification and verification is crucial because it is considered as a reliable solution in establishing a person’s identity. Iris recognition is forecast to play a role in a wide range of other applications in which a person’s identity must be established or confirmed. These include electronic commerce, information security, entitlements authorization, building entry, automobile ignition, digital forensic and police applications, network access and computer applications, or any other transaction in which personal identification currently relies just on special possessions or secret (keys, cards, documents, passwords, PINs).

The probability of finding two people with identical iris pattern is almost zero [1]. That's why iris recognition technology is becoming an important biometric solution for people identification in access control as networked access to computer application [2]. Compared with other biometric signatures mentioned above, the iris is generally considered more stable and reliable for identification [4-6].

One of the most important steps in iris recognition systems is iris localization, which is related to the detection of the exact location and contour of the iris in an image. (i.e it defines the inner and outer boundaries of iris region) Obviously, the performance of the identification system is closely related to the precision of the iris localization step [4]. Some previous iris segmentation approaches assume that both inner and outer boundaries of iris as a circle [31], while some assume that the boundaries can be modeled as both eclipse and circle respectively.

To improve the quality of segmentation /localization (i.e inner and outer boundaries of iris region), the researchers propose a new method based on development of an algorithm that uses the concept of Cartesian co-ordinate system and the use of the method for the computation of radii which are subsequently used to outline the inner and outer boundaries of the iris thus localizing it. The parameters captured to represent the eclipse are represented as objects. The new algorithm is simple, stable, robust, compute fast and flexible.

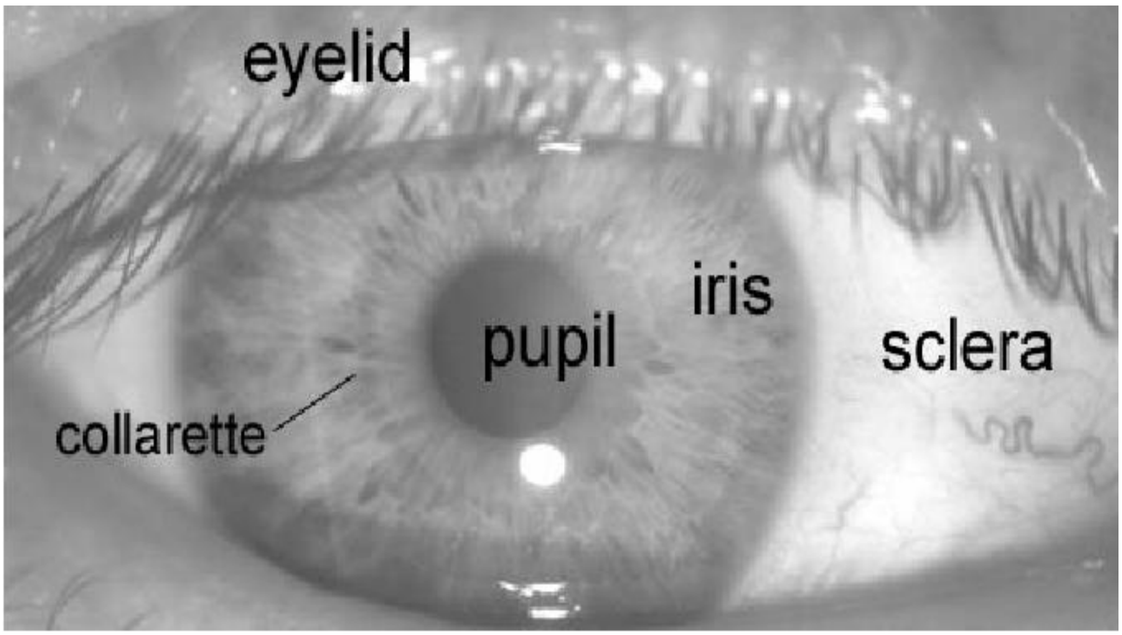

Figure 1: Anatomy of a frontal image of the eye [10]

2. LITERATURE REVIEW

2.1 The Human Iris

The iris is a muscle within the eyes that regulates the size of the pupil, controlling the amount of light that enters the eye. It is the colored portion of the eye with coloring based on the amount of melatonin pigment within the muscle. Melatonin pigment is a hormone produced by the pineal gland that affects the physiological changes related to time/lighting cycles. The iris is also an annular area between the pupil and the white sclera in the eye; it has many interlacing features such as stripes, freckles, coronas, radial furrow, crypts, zigzag collarette, rings etc collectively referred to as texture of the iris (see Figure 1). This texture is well known to provide a signature that is unique to each subject. In fact, the operating probability of false identification by the Daugman algorithm [5] can be of the order of 1 in 10^{10}.

The Iris lies between the cornea and the lens of the human eyes. The iris image is shown in figure 1. The iris is perforated close to its center by a circular aperture. This is known as Pupil. The pupil size can vary from 10% to 80% of the iris diameter. The iris diameter is 12mm.

The Human iris consisted of three boundaries. The boundaries are shown in figure 2. The first boundary is the inner boundary which lies between the pupil and the iris. The pupil also has a low grey level and looks dark in the eyes image. The second boundary is an outer boundary. The outer boundary is between the iris and the sclera and the last boundary is the collarette boundary.

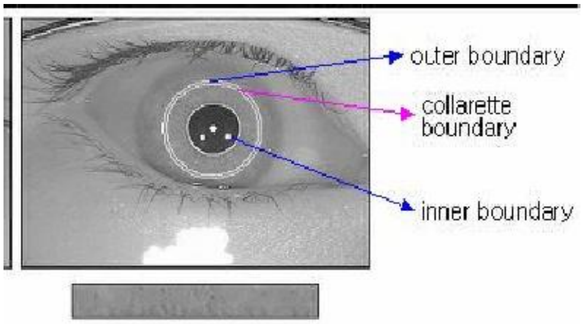

Figure 2: Image of the boundaries and the localization iris area [30]

2.2 Overview of Iris Recognition

Iris recognition is a method of biometric authentication that uses pattern-recognition techniques based on high-resolution images of the irides of individual's eyes [8]. It combines pattern recognition, computer vision and statistics. As a physiological biometrics, iris recognition aims to identify persons using iris characteristics of human eyes. It is a process of recognizing a person by analyzing the random pattern of the iris. Recently, iris recognition has received increasing attention due to its high reliability [30]. It can serve as a living password that one need not to remember but always carries along.

Iris recognition can be done by image processing. Image processing can be used to extract the iris pattern from a digitized image of the eyes. From the mathematical function, these biometric templates can represent the unique information of an iris. This allows comparison to be made between templates. To use the iris recognition system, the subject eye is first photographed and then a template is created for their iris region. The template is then compares against all users in the system. If the template matching is found, the user is identified and access is granted. If no match is found, the subject remains unidentified.

Iris recognition efficacy is rarely impeded by glasses or contact lenses [8]. Iris technology has the smallest outlier (those who cannot use/enroll) group of all biometric technologies. Because of its speed of comparison, iris recognition is the only biometric technology well-suited for one-to-many identification [8]. A key advantage of iris recognition is its stability, or template longevity, as, barring trauma, a single enrollment can last a lifetime [8].

The idea of using iris patterns for personal identification was originally proposed in 1936 by ophthalmologist Frank Burch [7]. In 1985 two ophthalmologists, Aran Safir and Leonard Flom, proposed the concept that no two irides are alike and were awarded a patent for the iris indetification concept in 1987, and in 1989 they asked John Daugman to try to create actual algorithms for iris recognition. These algorithms, which Daugman patented in 1994 are owned by Iridian Technologies/Securimetrics and are the basis for all current iris recognition systems and products.

2.3 Advantages of Iris Recognition

The iris of the eye has been described as the ideal part of the human body for biometric identification for several reasons [8]:

- The iris is not subject to deleterious effects of ageing, its radial pattern/features remain stable and fixed from about one year of age until death.
- The iris is an internal organ that is well protected against damage, ware and external environment behind the cornea and eyelid.
- The probability of finding two identical irises is close to zero.
- Each iris is different, even between identical twins or between left and right iris of an individual.
- An iris scan is similar to taking a photograph and can be performed from about 10 cm to a few meters away. There is no need for the person to be identified to touch any equipment that has recently been touched by a stranger, thereby eliminating an objection that has been raised in some cultures against fingerprint scanners, where a finger has to touch a surface, or retinal scanning, where the eye can be brought very close to a lens (like looking into a microscope lens).
- The originally commercially deployed iris-recognition algorithm, John Daugman's IrisCode, has an unprecedented false match rate (better than 10^{-11}).

While there are some medical and surgical procedures that can affect the colour and overall shape of the iris, the fine texture remains remarkably stable over many decades. Some iris identifications have succeeded over a period of about 30 years.

2.4 Disadvantages of Iris Recognition

- Iris scanning is a relatively new technology and is incompatible with the very substantial investment that the law enforcement and immigration authorities of some countries have already made into fingerprint recognition [8].

- The iris is a very small organ with radius about 11 mm to scan from a distance [33].
- It is a moving target and can be obscured by objects such as the eyelid, eyelashes and reflections.
- As with other photographic biometric technologies, iris recognition is susceptible to poor image quality, with associated failure to enroll rates. [7]
- The iris is located behind a curved, wet, reflecting surface.

3. IRIS RECOGNITION SYSTEM

An iris-recognition algorithm first has to identify the approximately concentric circular outer boundaries of the iris and the pupil in a photo of an eye. The set of pixels covering only the iris is then transformed into a bit pattern that preserves the information that is essential for a statistically meaningful comparison between two iris images. The mathematical methods used resemble those of modern lossy compression algorithms for photographic images [8].

A typical iris recognition system generally consists of the following basic modules[3]:

I. Image acquisition, iris location, and pre-processing,

II. Iris texture feature extraction and signature encoding, and

III. Iris signature matching for recognition or Verification

Before recognition of the iris take place, the iris is located using landmark features. These landmark features and the distinct shape of the iris allow for imaging, feature isolation and extraction.

In Module I an image containing the user's eye is captured (i.e an eye has to be taken as an image) and the iris is localized (i.e the inner and outer boundary (pupil and sclera) of the iris is located.) Then the image that contained the iris is preprocessed to normalize the scale and illumination of the iris by transforming the localized iris image from Cartesian co-ordinates to Polar co-ordinates system unwrapping the iris and mapping all the point within the boundary of the iris. Localization of the iris is an important step in Iris recognition because if done improperly, resultant noise (e.g eyelashes, reflections, pupils and eyelids) in the image may lead to poor performance. Iris imaging requires the use of high quality digital camera.

In Module II, as earlier mentioned the iris contains important features such as stripes, freckles, coronas etc which are collectively referred to as texture of the iris. All these features are extracted using different algorithms i.e features extraction is the process of extracting information from the iris image. Using the various algorithm, upon imaging an iris, the segment of the iris has to be filtered and mapped into phasors(vectors). These phasors include information on the orientation and spatial frequency ("what"of the image) and the position of these areas ("where" of the image). This information is used to encode iris pattern. Iris patterns are described by an IrisCodes using phase information collected in the phasors. The phase is not affected by contrast, camera gain, or illumination levels. The phase characteristics of an iris can be described using 256 bytes of data using a polar coordinate system.

In Module III, recognition is performed in which two iris codes are compared. The amount of difference between two IrisCodes – Hamming Distance (HD) is used as a test of statistical independence between two IrisCodes. If the HD indicates that less than one-third of the bytes in the IrisCodes are different, the IrisCodes fails the test of statistical significance, indicating that the Iriscodes are from the same iris. Therefore, the key concept of Iris recognition is failure of the test of statistical independence.

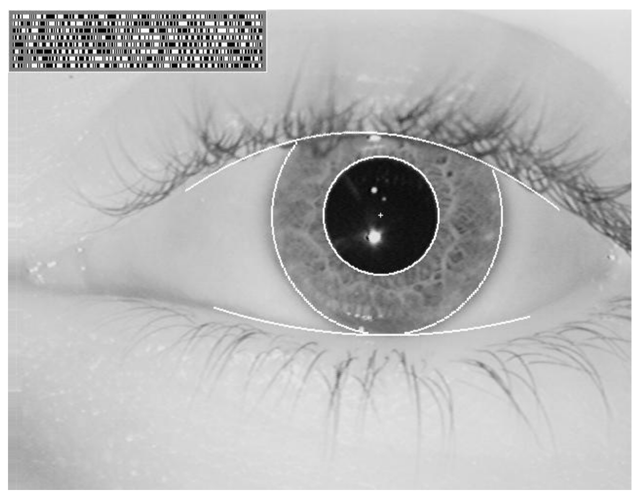

Figure 3: Localized iris with Iriscodes [6]

4. PREVIOUS WORK ON IRIS LOCALIZATION

4.1 Daugman's Algorithm

In [4], Daugman introduced a circular edge detection operator for iris localization, as follows:

$$\max_{(r,x_0y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial_r} \oint_{r,x_0y_0} \frac{I(x,y)}{2\pi r} ds \right| \qquad (1)$$

operators that search over the image domain (x,y) for the maximum in the blurred partial derivative, with respect to increasing radius r, of the normalized contour integral of $I(x,y)$ along a circular arc ds of radius r and center coordinates (x_o,y_o). The symbol * donates convolution and G(r) is a Gaussian filter used as a smoothing function. It is obvious that the results are inner and outer boundaries of iris. First, the inner boundary is localized, due to the significant contrast between iris and pupil regions. Then, outer boundary is detected, using the same operator with different radius and parameters.

4.2 Hough Transform

Wildes [12], Kong and Zhang [25] and Ma et al. [24] use Hough transform to localize irises. It uses the gradient-based Hough transform to decide the two circular boundaries of an iris. It includes two steps. First a binary edge map is generated by using a Gaussian filter. Then, votes in a circular Hough space are analyzed to estimate the three parameters of one circle (x_0, y_0, r). A Hough space is defined as:

$$H(x_0, y_0, r) = \sum_i H(x_i, y_i x_0, y_0, r) \qquad (2)$$

Where:

$(x_i, y_i) \qquad = An\ edge\ pixel$

$$H(x_i, y_i, x_0, y_0, r) = \begin{cases} 1\ if\ (x_i, y_i) is\ \ on\ the\ circle\ (x_0, y_0, r) \\ 0\ otherwise \end{cases}$$

The location (x_0, y_0, r) with the maximum value of $H(x_o, y_o, r)$ is chosen as the parameter vector for the strongest circular boundary.

4.3 Other Localization Methods

Other researchers use methods similar to the described segmentation methods. Tisse et al. [11] proposed a segmentation method based on Integro-differential and the Hough transform. Huang et al. [26] proceeded to iris segmentation by simple filtering, edge detection and Hough transform. Boles and Boashah [13], and Lim et al. [14], mainly focused on the iris image representation and feature matching without introducing a new method for segmentation. Noh et al [15] also did not propose a new method for segmentation, Daugman Algorithm was utilized. Tan et al [17, 18] proposed a segmentation method based on canny operator and Hough transform. Tang et al [27] also proposed a new segmentation method based on Support Vector Machines (SVM) classifier to locate the iris outer boundary and Dilation operator of morphological to locate the iris inner boundary. Gupta et al [28] used Hough transform and circular summation of intensity approach. Yi et al [29] used canny edge detection for its iris segmentation. Also Du et al. [16] proposed the iris detection method based on the prior pupil segmentation. Yahaya et al [31,32] proposed a segmentation method based on direct least square fitting of ellipse , Integro-differential algorithm and also Hough Transform.

Considering the above mentioned methods, we can state the following remarks:

- In Daugman algorithm, Hough transform, usually inner boundaries are detected by circle fitting techniques. This is a source of error, since the inner boundaries are not exactly circles [31, 32].
- Computationally, they are tedious. Especially, Wildes method is very computationally demanding because it introduces lots of edge points of other objects, such as eyelashes and eyelids, in Hough transform [12]
- They are lacking in robustness.

5. METHODOLOGY: ALGORITHM FOR IRIS LOCALIZATION

The methodology used is the development of an algorithm that captures the Cartesian coordinates of the center of the eye image and two other points for each of the boundaries(inner and outer). These points are used to compute the radii of the boundaries and then used to localize the iris by drawing a perfect geometry that fits the boundaries. The center points and the computed radii serve as the parameters which are stored as objects- one for the inner boundary and another for the outer boundary. The steps involved in the iris localization process are summarized as follows:

Step 1: Create Object1, Object2 (Objects are composite data types that stores the parameters representing the geometry for the boundaries of the iris, the parameters include x,y, r1,r2 where x, y are co-ordinates of the center of the eye image and radius1, radius2 respectively)

Step 2: Capture the co-ordinate of the centre of the image of the eye.

Step 3: Capture the co-ordinates of 2 points on the inner boundaries of the iris (one of the 2 points is vertically above the centre of the eye and the other is horizontally eastward of the centre of the eye i.e pX, pY respectively)

Step 4: Compute: radius1 (r1) as distance between the centre of the eye image and the vertical points co-ordinates.

Comp $$r1 = \sqrt{x_1^2 + y_1^2} \quad (3)$$

Where $x_1 = pX.x_1 - pcentre.x_1$

$y_1 = pX.y_1 - pcentre.y_1$

radius2 (r2) as distance between the center of the eye image and the horizontal eastward co-ordinates.

$$r2 = \sqrt{x_2^2 + y_2^2} \quad (4)$$

Where

$$x_2 = pY.x_2 - pcentre.x_2$$
$$y_2 = pY.y_2 - pcentre.y_2$$

Step 5: Draw an Eclipse using the co-ordinates of the centre of the eye, radius1 and radius2 (r1 and r2).

Step 6: Repeat step 3 to 5 for the outer boundary.

Step 7: Store the co-ordinates of the centre of the eye image and the 2 computed radius for the inner boundary into Object1.

Store the co-ordinates of the centre of the eye image and the 2 computed radius for the outer boundary into Object2.

Step 8: Stop.

6. CONCLUSION

One of the most important steps in iris recognition systems is iris localization, which is related to the detection of the exact location and contour of the iris in an image. (i.e it defines the inner and outer boundaries of iris region) Obviously, the performance of the identification system is closely related to the precision of the iris localization step. Some previous iris segmentation approaches assume that both inner and outer boundaries of iris as a circle, while some assume that the boundaries can be modeled as both eclipse and circle respectively. Usually, the inner boundaries are detected by circle fitting techniques. This is a source of error, since the inner boundaries are not exactly circles. In noisy situations, the outer boundary of iris does not have sharp edges.

In this research work the algorithm developed can accurately define both the inner and outer boundaries of the iris irrespective of the geometry it may be (circle or eclipse) by capturing the parameters that represents the geometry. The new algorithm is simple, robust, computes accurately and flexible.

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