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Iris Preprocessing

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***Abstract*— In this paper localisation of the inner and outer boundaries of the iris is done by finding the maximum blurred partial derivative. Normalization of iris has been achieved by projecting the original iris in a Cartesian coordinate system into a doubly dimensionless pseudopolar coordinate system. CASIA Iris Database has been used to test the algorithms.**

***Keywords*— Biometrics, Human Identification, Iris localization, Iris Normalisation**

I. INTRODUCTION

Biometrics system has the potential for application to identification and verification of individuals for controlling access to secured areas, many countries support biometrics research after 9 11. Iris recognition has become an active research since the concept of an iris recognition system was first proposed by Flom and Safir in 1987. Iris recognition is one of the most reliable noninvasive methods of personal identification owing to the stability of the iris over one's lifetime. In the year 1994, John Daugman patented his "biometrics personal identification system based on iris analysis"[1][3][4].

The identification based on iris pattern has some advantages, which are:

1) Iris is a highly protected, internal organ of the eye
2) Iris is visible from a distance
3) Iris patterns possess a high degree of randomness
4) Changing the size of the pupil confirms natural physiology
5) Limited genetic penetrance
6) Iris is stable throughout life

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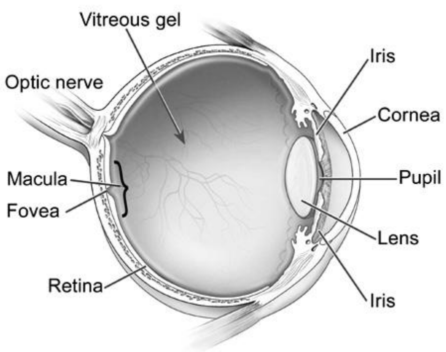

Figure 1: Anatomy of human eye

In the iris alone, there are over 400 distinguishing characteristics, or Degrees of Freedom (DoF), that can be quantified and used to identify an individual. Although, approximately 260 of those are possible to be captured for identification, these identifiable characteristics include: contraction furrows, coronas, stripes, striations, pits, collagenous fibers, filaments, crypts (darkened areas on the iris), serpentine vasculature, rings, and freckles. Due to these unique characteristics, the iris has six times more distinct identifiable features than a fingerprint.

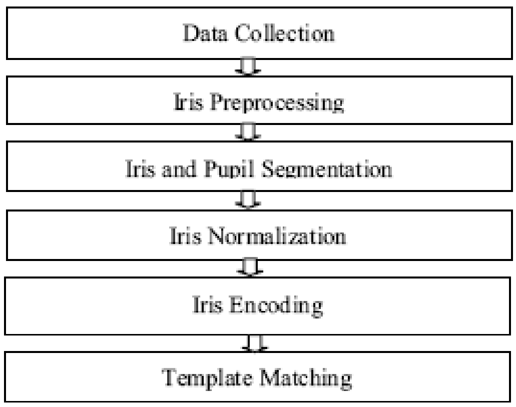

Figure 2: Stages of iris-based recognition algorithm

Human iris identification process is basically divided into four steps:

- Localization - The inner and the outer boundaries of the iris are calculated.
- Normalization - Iris of different people may be captured in different size, for the same person also size may vary because of the variation in illumination and other factors.
- Feature extraction - Iris provides abundant texture information. a feature vector is formed which consists of the ordered sequence of features extracted from the various representation of the iris images.
- Matching - The feature vectors are classified through different thresholding techniques like Hamming Distance, weight vector and winner selection, dissimilarity function, etc.

II. Proposed Work

Iris localization is considered the most difficult part in iris identification algorithms because it defines the inner and outer boundaries of iris region used for feature analysis [5]. The main objective here is to remove any non-useful information, namely the pupil segment and the part outside the iris (sclera, eyelids, skin). The localization algorithm makes use of the first derivative of the image to the find the boundaries of the iris. The normalisation process produces iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. The normalisation algorithm projects the iris disk to a rectangular region with each sub- prefixed size.

III. Iris Image Preprocessing

Iris image pre-processing is an important task to be performed before the localization of the iris boundaries in order to obtain efficient results. Before performing the localisation the image is scaled, which reduces complexity significantly by scaling down all images to a constant image size in order to speed up the whole process. The minimum and maximum radii of the iris are also scaled. The image is scaled down to a constant image size in order to speed the entire process of localisation. The contrast of image is enhanced to have sharp variation at image boundaries using histogram equalization. This contrast enhanced image is used for finding the iris and the pupillary boundaries. The localization algorithm can fail where there is noise in the eye image, such as from reflections so the specular reflections which corrupt the iris pattern are also removed.

IV. Iris Localisation

Iris localization is considered the most difficult part in iris identification algorithms because it defines the inner and outer boundaries of iris region used for feature analysis.
The first step in iris localization is to detect the outer radius of iris patterns. The centre of iris can be used to detect pupil which is the black circular part surrounded by iris tissues.

The important steps involved are:

1. Outer iris localization
2. Pupil detection

Because of the felicitous circular geometry of the iris the task of localizing the inner and outer boundary of the iris can be accomplished for a raw input image I(x,y) by searching over the image domain (x,y) for the maximum in the blurred partial derivative, with respect to the increasing radius r, of the normalized contour integral of I(x,y) along a circular arc *ds* of radius *r* and center coordinates (*x*0, *y*0).

$$\max_{(r,x_p,y_o)}\left|G_\sigma(r) * \frac{\partial}{\partial r}\oint_{r,x_o,y_0}\frac{I(x,y)}{2\pi r}ds\right|$$

where $G(r) = (1/\sqrt{2\pi}\sigma)e^{-((r-r_0)^2/2\sigma^2)}$ is a radial Gaussian with center r_0 and standard deviation σ that smoothes the image to select the spatial scale of edges under consideration. The smoothed image is then scanned for a circle that has a maximum gradient change, which indicates an edge. The algorithm is done twice, first to get the iris contour then to get the pupil contour.

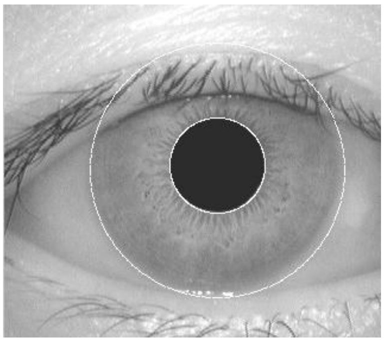

Figure 3: Localization of the iris boundaries

V. Iris Normalisation

The normalisation process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. Another point of note is that the pupil region is not always concentric within the iris region, and is usually slightly nasal, so remapping is done.
The normalisation algorithm remaps each point within the iris region to a pair of polar coordinates (*r*, θ) where *r* is on the interval [0,1] and θ is angle [0,2π].

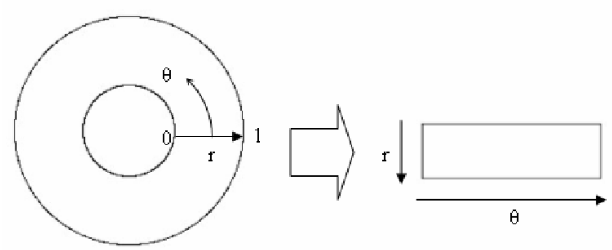

Figure 4: Mapping of Cartesian co-ordinates into polar co-ordinates

The remapping of the iris region from *(x,y)* Cartesian coordinates to the normalised non-concentric polar representation is modelled as

$$I(x(r, \theta), y(r, \theta)) \rightarrow I(r, \theta)$$

with

$$x(r, \theta) = (1-r)xp(\theta) + rxl(\theta)$$

where *I(x,y)* is the iris region image, *(x,y)* are the original Cartesian coordinates, *(r, θ)* are the corresponding normalised polar coordinates, and and are the coordinates of the pupil and iris boundaries along the θ direction. The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalised representation with constant dimensions. In this way the iris region is modelled as a flexible rubber sheet anchored at the iris boundary with the pupil centre as the reference point.

Figure 5: Iris Normalisation

VI. EXPERIMENTAL RESULT

The algorithms have been implemented in Matlab 7.0. In order to evaluate the algorithms CASIA v1 and CASIA Iris-Interval database .

CASIA Iris Image Database Version 1.0 (CASIA-IrisV1) includes 756 iris images from 108 eyes. The eye images are mainly from persons of Asian descent, whose eyes are characterised by irises that are densely pigmented, and with dark eyelashes. Due to specialised imaging conditions using near infra-red light, features in the iris region are highly visible and there is good contrast between pupil, iris and sclera regions. For each eye, 7 images are captured in two sessions with our self-developed device CASIA close-up iris camera, where three samples are collected in the first session and four in the second session. All images are stored as BMP format with resolution 320*280.

For the CASIA database version 1, the segmentation technique managed to correctly segment the iris region from 658 images out of 756 eye images, which corresponds to a success rate of around 87.03%. CASIA Iris-Interval database of CASIA v4 provided more accurate results with 97.95% success rate. The PT-UBIID-v.02 images proved problematic and the segmentation process correctly identified iris and pupil boundaries for only 65% of the eye images.

The problem images had small intensity differences between the iris region and the pupil region. One problem faced with the implementation was that it required different parameters to be set for each database. These parameters were the radius of iris and pupil to search for, and threshold values.

The normalisation process proved to be successful. However, the normalisation process was not able to perfectly reconstruct the same pattern from images with varying amounts of pupil dilation, since deformation of the iris results in small changes of its surface patterns.

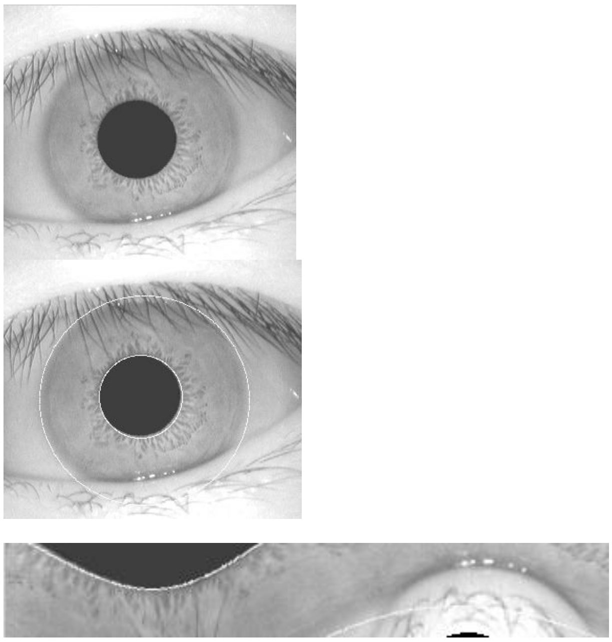

Figure 6: CASIA V1 014_image 1_1.bmp (top left), segmented image (top right) and normalised image (bottom)

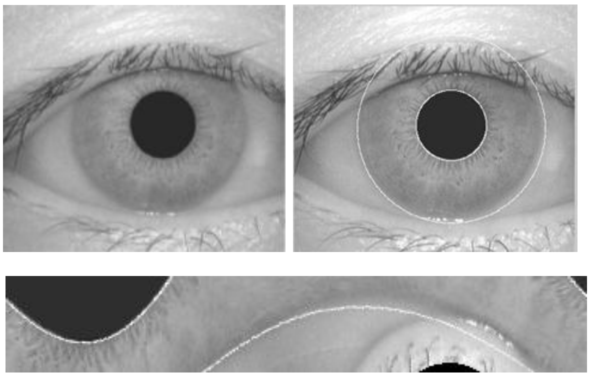

Figure 7: CASIA V1 image 024_2_4.bmp (top left), segmented image (top right) and normalised image (bottom)

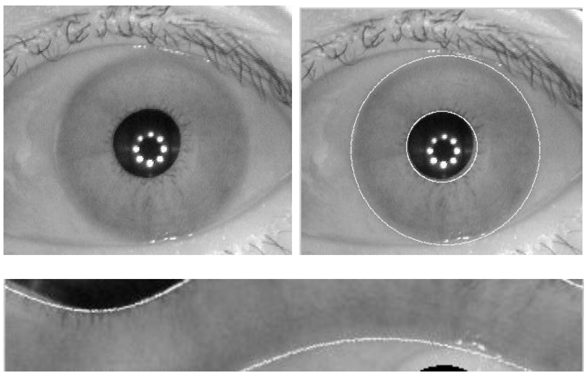

Figure 8: CASIA V4 Interval image S1025L01.jpg (top left), segmented image (top right) and normalised image (bottom)

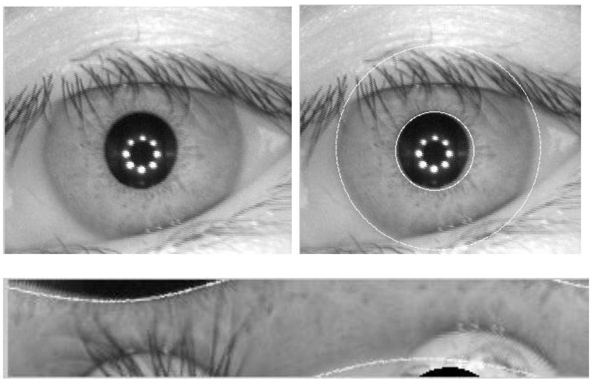

Figure 9: CASIA V4 Interval S1014L02.jpg (top left), segmented image (top right) and normalised image (bottom)

VII. Conclusion

This paper describes a practical iris preprocessing algorithm, and then tests the algorithms using two iris databases. In the test results the segmentation algorithm accurately localizes the boundaries of the iris. Since it works with raw derivative information, it does not suffer from the thresholding problems of the Hough transform. The segmented images have been efficiently normalised so that it may have fixed dimensions. From the experimental results, it is found that the technique is optimized enough to be applied to various real applications. The future work will focus on implementation of iris feature extraction, encoding and matching.

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