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An Analysis on Iris Segmentation Method for Non Ideal Iris Images like off-axis angle and distance acquired

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--ABSTRACT--
ABSTRACT: Iris segmentation is initial and crucial operation performed in iris recognition. The precise iris segmentation is essential for the success of the iris recognition, and therefore the high performance for iris recognition system. Most iris segmentation approaches proposed in the existing literature require iris images taken in ideal conditions, which prevents their effective real-time applications and makes the system highly sensitive to noise. This paper presents a fast and efficient iris segmentation methodology for iris images taken in non-ideal conditions especially for off-axis iris images and distantly acquired images. First we describe the procedure for segmenting off axis iris images next for distantly acquired images. Three major procedures involved in the proposed iris segmentation approach, namely iris/pupil detection, boundary localization, and Unwrapping, were carefully designed in order to avoid redundant and unnecessary image processing, and most importantly, to protect the integrity of iris quality information. The iris images are taken from CASIA V4 database. As a consequence, the iris recognition system that incorporates the proposed iris segmentation algorithm is capable of offering recognition performances comparable with those reported by other state-of-the-art methods.

KEYWORDS: *Iris segmentation, Off-axis, Non-ideal, distance, CASIA 4*

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I. INTRODUCTION

Human identification based on iris is becoming a famous tool rapidly as compared to other biometric recognition techniques due to its unique epigenetic pattern remains stable [1]. The fast growth in the field of image processing makes it very affordable and automated for digitized iris images. Evenly, the characterization and classification spatial iris patterns help to recognize the individual comfortably. The cornea and the eyelid act as a shield for the iris and protect it from adverse environmental effects. These in all inherent properties makes iris recognition as the most suitably security solution [2]. The very first automated iris recognition concept was given by Flom and Safir [3] in the year 1987 based on the fact that varying the illumination to force pupil to a predetermined size to overcome with the problem of contraction and expansion of pupil. But the imaging conditions they addressed were not that practical. Then the most widely used methodology was developed by Daugman [4], has used multi-scale quadrature wavelets to extract texture phase features of the iris to generate iris templates and compared the difference between a pair of those by computing their Hamming distance (HD). Another popular iris recognition system developed in the same year was Wildes' system [5] which also provides high accuracy. Wildes et al. have represented the iris pattern with a Laplacian pyramid constructed with four different resolution levels and has used the normalized correlation to determine whether the input image and the test image are from the same class. Later, Boles and Boashash [6] have used 1-D wavelet transform for calculating zero-crossing representation at various resolution levels of a virtual circle on an iris image to characterize the texture of the iris. The current iris recognition techniques basically comprise four main stages: segmentation, normalization, feature extraction and matching.The distance image is an advantage in the identification of a human being over single eye images taken purposefully for iris recognition based security systems. Distance iris recognition facilitates quicker and easily adoptable recognition method. The advantages of employing recognition on the basis of two eyes are: (1) If the recognition fails with one eye, then the recognition with the other eye can provide correct result. (2) The recognition of a single person is done twice which provides the system an automatic verification for its output. (3) It is especially advantageous in case when a single eye of a person becomes defective. The major problem that is encountered while recognizing the iris images at distance is feature extraction. The features are not extracted properly that may reflect to poor recognition. An Iris On The Move System [6] is described which enables to capture iris images of sufficient quality for iris recognition while the subject is moving at a normal walking pace through minimally confining portal. Similar attempts for iris recognition of distance image are depicted in [8, 9]. In [8], the user can be identified from 10 metres if the head of the user stays fixed. In [9], a multi biometric system is presented, designed to identify users at a distance of 6 metres. It is very well known fact that the right and left irises of an individual are different and unique. It has been calculated that the chance of finding two randomly formed identical irises is on an almost astronomical order of 1 in 1078. The difference between the left and the right irises of the same person may be similar to the difference between the irises captured from different persons. Both the irises have similar genetic relationship but textual details for both the left and right iris are uncorrelated and independent. For example, an Afghan girl Sharbat Gula was first photographed in 1984 and then in 2002. Iris codes were computed and matched for both the photographs and it was observed that HD for left eye was 0.24 and for right eye was 0.31. It confirms that by the aging effect too, the resemblance between both irises remains same and unique. In view to further strengthening of the human identification, the new methodology is proposed in this manuscript for distance images and off axis angle iris images.

II. EXISTING SYSTEM

Iris recognition has some advantages over other biometric modalities. For example, most iris patterns are reported to remain unchanged over a life time, and they cannot be easily forged or modified. In addition, every person has his/her own unique iris pattern with high degrees of freedom. Therefore, many biometric researchers have used iris recognition for high confidence identification and this has led to extensive studies in developing iris recognition techniques in unconstrained environments, where the probability of acquiring non-ideal iris images is very high due to off-angles, noise, blurring and occlusion by eyelashes, eyelids, glasses, and hair. Fig. 1 shows some examples of non-ideal iris images [1] but most of the previous research on iris segmentation has focused on accurate detection with iris images which are captured in closely controlled conditions. Thus, applying these methods to non-ideal iris images often yields incorrect segmentation results, which deteriorates the recognition accuracy.

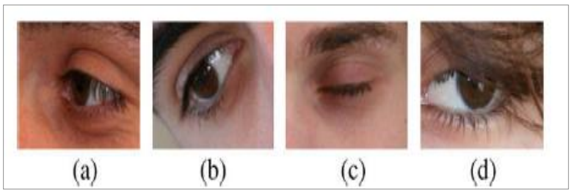

Figure 1: Non- ideal iris images.

The modern world has increasing demand for identification of human beings in widespread areas. The biometrics can provide a natural and convenient means for individual identification by examining the physical or behavioral traits of human beings(Jain, 2007). Among various biometrics identification technologies, iris recognition has been of particular research interest because of the characteristics of uniqueness, stability and non-invasiveness of iris(Daugman, 1993).In the past years, great advances have been made in constrained environments where the users are closely cooperative. The state of the art iris recognition techniques are reviewed by Bowyer et al. (2008). Recent research interest in the field has focused on recognition in less constrained imaging conditions. In such circumstances the iris images captured may be degraded due to off-axis imaging, image blurring, illumination variations, occlusion, specular highlights and noise(Proenc¸a et al., 2010).Robust iris recognition in such degraded images pose a grand challenge. Daugman (2007) reported some advances including accurate iris boundaries localization with active contour and image registration through Fourier-based trigonometry, among others. Proenca and Alexandre (2007) investigated a classification method which combines multiple signatures for noncooperative iris recognition.(Sun and Tan,2009) presented a general framework for iris feature representation based on ordinal measure.

III. PROPOSED SYSTEM

The proposed model described below introduces iris segmentation for two different cases of iris in non-ideal conditions. First, we give iris segmentation for Off-axis iris images. Second, for iris images acquired in distance. As per our convenient the maximum distance considered here is dual Segmentation Technique where the iris patterns of both left and right eye are used for better recognition performance, since both the eyes carries distinguishable features which signifies its uniqueness. The most distinctive feature of this model which makes it different from the existing model is that recognition doesn't rely purely on one eye. Therefore, if a person's one eye fails to match, there is another opportunity through which person can be recognized. An individual is recognized even if any of the two eyes matches. Since, recognition is performed for both the eyes, the verification becomes undisputable. Both the eyes undergoes with the basic steps of an IRS(Iris Recognition System) which is implemented using John Daugman's and Libor masek's iris recognition method [10] and extends the study of eyes pattern for distance images. Matching is performed against the optimized HD value computed. Optimized HD value is decided on the basis of various parameters that monitors recognition rate.

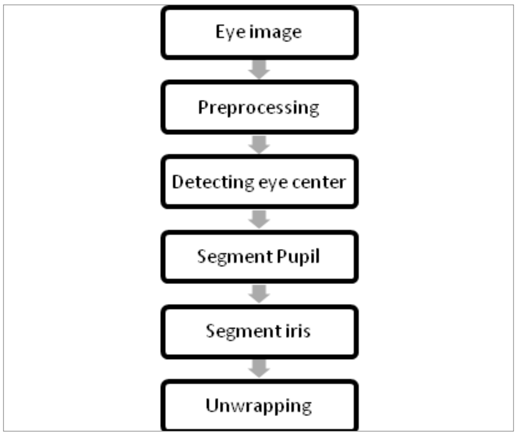

Figure 2: Proposed Architecture

An Iris Segmentation System for distant images and for off axis angle images comprises mainly five stages- (1) Pre-Processing (2) Detect Eye Center (3) Segment Pupil(4) Segment Iris (5) Unwrap iris. The processing for both left and right eye in case of distant images is similar which undergoes through stages 2 to5. These stages are discussed in detail below:

3.1 Preprocessing

It is initial stage in iris segmentation which can lead to iris recognition. In this stage, an input eye image of an individual is taken. As we concentrating on two subjects that is off-axis angle and distant iris images. The Off axis iris images are those whose pupil is turned to some angle from axis. For our convenient we are considering the off axis angle as less than 30 degrees. For second subject that is distant iris, the image should provide an explicit view of left and right eye. The primary motive is to extract the left and right eye from the input image. This can be performed through automatic cropping based on the manual distances calculated from localized pupil. Figure 3 shows input (a) Off axis (b) distance image obtained from CASIA IV database. Figure 4 shows the separated right and left eye from the input image for distant iris image.

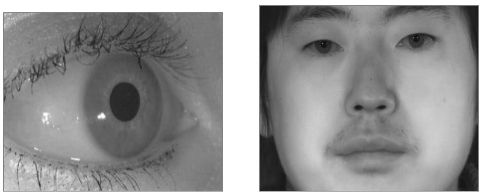

Figure 3: (a) Off axis angle (b) Iris at distance

Figure 4: Cropped Left and Right eye from sample images

3.2 Detect Eye Center

The next step is to detect the eye center. To detect Eye Center we apply Active Contour model .The basic idea of active contour models relies on detecting salient objects by evolving a curve or a surface subject to image based constraints. Let 2 Rd be the image domain and I : ! R be a given image function. In [9], Mumford and Shah proposed an energy functional to be minimized by a suitable contour C in for image segmentation.

$$E(I,C,\Omega) = \int_{\Omega} | I - I_0 |^2 \, dx + \lambda\Gamma(C) \qquad (1)$$

$$E(I,C,\mu,\bar{\mu},\lambda_1,\lambda_2) = \int_{\Omega out} |I - \bar{\mu}|^2 dx + \lambda_1 \int_{\Omega in} |I - \bar{\mu}|^2 \, dx + \lambda_2\Gamma(C) \qquad (2)$$

where Γ (C) is a regularization function for the contour C andλ is a non-negative constant weight. Minimizing the above energy function E results in an optimal contour that segments the image into a piecewise smooth image I that approximates the original image I0. In [6] Chan and Vese proposed an active contour model for segmenting images containing objects that have poor boundaries by proposing to minimize the following piecewise constant approximation to the Mumford and Shah energy function, where in and out represents the region inside and outside the contour C and λ1 and λ2 are two scalar constants that approximate the image intensities inside and outside the contour respectively. The first two terms seek to separate an image into two regions of constant image intensities. This minimization problem is converted into a level-set evolution equation by using a level set formulation. Due to its lack of explicit dependence on gradient or edge information, this model is very well suited to detect objects whose boundaries are not necessarily defined by gradients or with very smooth boundaries. We aim to leverage this property of the Chan-Vese technique to segment blurred out and low-contrast iris images.

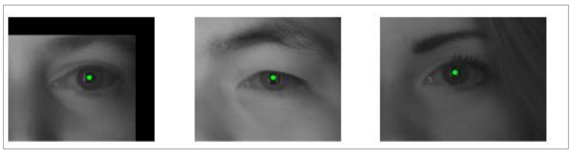

Figure 5: Detected eye center.

3.3 Segmentation of pupil/Iris

The segmentation stage detects the pupillary and limbus boundaries to isolate the iris region from an input eye image. It also identifies regions where the eyelids and eyelashes interrupt the limbus boundary's contour. It is implemented using circular Hough Transform. Hough transform for limbus boundary was performed first then for pupillary boundary to reduce the search area.

Step 1: Apply Canny edge detection to the input image resulting in an edge map.

Step 2: Vertical gradient is taken for iris/sclera boundary.

Step 3: Compute horizontal as well as vertical gradient for iris/pupil boundary.

Step 4: Choose in the Hough space using the resultant edge map, the radius and centre coordinates of the circle which is the corresponding to the maximum point in the Hough space. Circle parameters define the circle as follows:

$$x_c + y_c - r^2 = 0 \qquad (5)$$

Steps taken For Eyelid Isolation:

1. A line is fitted to the upper and lower eye lid using linear Hough transform.
2. The second horizontal line is drawn in such a way that intersects the first line at the iris edges which is closest to the pupil. For eyelashes isolation, thresholding technique was adopted from the perception that the eye lashes are the darkest region of an eye. Different thresholding values were chosen for left and right eye.

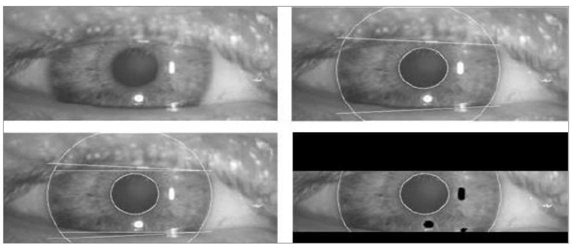

Figure 6: Segmented Left and Right eye from sample images

IV. UNWRAPPING

Once the iris region is segmented, the next stage is to Unwrap, to enable generation of the iris code and their comparisons. Since there is always variations in the eye, like change in optical size of the iris, position of pupil in the iris, and the iris orientation change to individual person, it is required to normalize the iris image, so that the representation is common to all, with related dimensions. Normalization process involves unwrapping the iris and converting it into its polar equivalent. It is done using Daugman's Rubber sheet model [10]. The center of the pupil is considered as the reference point and a remapping formula is used to convert the points on the Cartesian scale to the polar scale. The Normalization 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 $[0,2\pi]$.

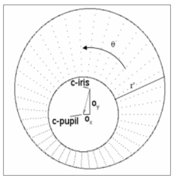

Figure 7: Normalization process

$$r' = \sqrt{\alpha\beta} \pm \sqrt{\alpha\beta^2 - \alpha - r_1^2}$$

Where r_1 = iris radius

$$\alpha = o_x^2 + o_y^2$$

$$\beta = \cos\left(\pi - \arctan\left(\frac{o_y}{o_x}\right) - \theta\right)$$

The radial resolution was set to 100 and the angular resolution to 2400 pixels. For every pixel in the iris, an equivalent position is found out on polar axes. The normalized image was then interpolated into the size of the original image, by using the interp2 function. The parts in the normalized image which yield a NaN, are divided by the sum to get a normalized value.

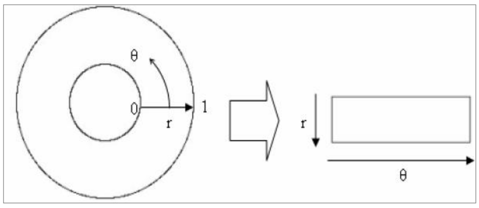

Figure 8: Unwrapping the iris

V. CONCLUSION

Recognition of humans from their iris patterns under very harsh imaging conditions is a challenging task. Accurate iris segmentation is the main bottleneck to improved iris recognition under these conditions. In this paper we proposed a region based active contour segmentation algorithm which is more suited to segment iris regions under difficult imaging scenarios. A new iris segmentation method for non-ideal iris images has been proposed, especially for off-axis iris images and distantly acquired images. A unified method is proposed for step by step to recognition of iris images taken in for non-ideal environment. We introduce a robust algorithm for localizing the outer iris boundary, This solves the non-circular boundary localization problem induced by the off-axis imaging or pose variation. Iris images taken from a distance of 6 meters are recognized which can be implemented in real time applications where objects are far from the camera.

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