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A REVIEW ON IRIS SEGMENTATION METHODS

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ABSTRACT

Iris recognition is nowadays considered as one of the most accurate biometric recognition techniques. However, the overall performances of such systems can be reduced in non-ideal conditions, such as unconstrained, on-the-move, or non-collaborative setups. In particular, a critical step of the recognition process is the segmentation of the iris pattern in the input face/eye image. This process has to deal with the fact that the iris region of the eye is a relatively small area, wet and constantly in motion due to involuntary eye movements.This paper presents an up-to-date survey of iris segmentation algorithms that had been developed in literatures. It discusses the centrality of segmentation stage to effectiveness of iris recognition system. It identifies the methods used in the segmentation algorithms, the accuracy of the method and some noticed limitation(s) of the reviewed algorithms.

Keywords: Biometrics, iris, iris database, iris recognition, iris segmentation.

I. INTRODUCTION

With an increasing emphasis on security, iris recognition is becoming most reliable biometric technology. Iris recognition system consists of some several stages such as iris image capturing, iris boundary localization, normalization, enhancement, feature extraction, feature selection, matching etc. Segmentation is a process of finding the most useful portion of the iris image for further processing. It is done by localizing pupil and iris boundaries, eyelashes and eyelids. In case there is no proper segmentation, next stages of iris recognition will suffer and false data will be generated as template which in turn affects the recognition rates. To speed iris segmentation, the iris has been roughly localized by a simple combination of Gaussian filtering, canny edge detection, and Hough transform. Hough Transform is used to deduce the radius and center of the pupil and iris circles.Iris localization is the key stage among them. In the Iris localization stage, the inner and outer boundaries of the iris are detected along with the center co-ordinates of pupil and iris. A critical step in an iris recognition system is to segment automatically and reliably the iris from the captured iris images. The goal of iris segmentation is to localize the iris from pupil, sclera, eyelids, eyelashes and reflections. However, it is difficult to localize the iris, especially for the images captured by hand-held capture device. Iris localization has emerged as an important research area with a diverse set of applications including human computer interaction, assistive systems for drivers or disabled people, and biometrics. A significant numbers of iris segmentation techniques have been developed. Two most popular techniques are based on using an integro-differential operator used by Daugman and the Hough transform which is used by Wildes respectively. The performance of an iris segmentation technique is greatly dependent on its ability to precisely isolate the iris from the other parts of the eye.

II. EXISTING IRIS SEGMENTATION TECHNIQUES

I) Daugman's Integro-differential Operator-

Daugman makes use of an integro-differential operator for locating the circular iris and pupil regions, and also the arcs of the upper and lower eyelids. Image focus assessment is performed in real time (faster thanvideo frame rate) by measuring spectral power in middle andupper frequency bands of the 2-D Fourier spectrum of eachimage frame and seeking to maximize this quantity either bymoving an active lens or by providing audio feedback to Subjectsto adjust their range appropriately. The video rate executionspeed of focus assessment (i.e., within 15 ms) is achievedby using a bandpass 2-D filter kernel requiring only summationand differencing of pixels, and no multiplications, withinthe 2-D convolution necessary to estimate power in the selected2-D spectral bands. Details are provided in the Appendix.Images passing a minimum focus criterion are then analyzedto find the iris, with precise localization of its boundaries using acoarse-to-fine strategy terminating in single-pixel precision estimatesof the center coordinates and radius of both the iris andthe pupil. Although the results of the iris search greatly constrainthe pupil search, concentricity of these boundaries cannot be assumed.Very often the pupil center is nasal, and inferior, to theiris center. Its radius can range from 0.1 to 0.8 of the iris radius.Thus, all three parameters defining the pupillary circle must beestimated separately from those of the iris. A very effective integro-differentialoperator for determining these parameters is.

ma………… (1.1)

Where $I(x, y)$ is the eye image, r is the radius to search for, $G_\sigma(r)$ is a Gaussian smoothing function, and $s$is the contour of the circle given by r, x_0, y_0. The operator searches for the circular path where there is maximum change in pixel values, by varying the radius and centre$x$ and y position of the circular contour. The operator is applied iteratively with the amount of smoothing progressively reduced in order to attain precise localisation. Eyelids are localized in a similar manner, with the path of contour integration changed from circular to an arc.

The integro-differential can be seen as a variation of the Hough transform, since it too makes use of first derivatives of the image and performs a search to find geometric parameters. The operator in (1.1) serves to find both the pupillary boundary and the outer (limbus) boundary of the iris, although the initial search for the limbus also incorporates evidence of an interior pupil to improve its robustness since the limbic boundary itself usually has extremely soft contrast when long wavelength NIR illumination is used. Once the coarse-to-fine iterative searches for both these boundaries have reached single-pixel precision, then a similar approach to detecting curvilinear edges is used to localize both the upper and lower eyelid boundaries. The path of contour integration in (1.1) is changed from circular to arcuate, with spline parameters fitted by statistical estimation methods to model each eyelid boundary. Images with less than 50% of the iris visible between the fitted eyelid splines are deemed inadequate. [1]

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II) Hough Transform –

The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and iris regions. An automatic segmentation algorithm based on the circular Hough transform is employed by Wildes et al. [2]. Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the centre coordinates x_c and y_c, and the radius *r*, which are able to define any circle according to the equation

.... (2.1)

A maximum point in the Hough space will correspond to the radius and centre coordinates of the circle best defined by the edge points. Wildes et al. and Kong and Zhang also make use of the parabolic Hough transform to detect the eyelids, approximating the upper and lower eyelids with parabolic arcs, which are represented as;

$$x(-(x-h_j)\sin\theta_j + (y-k_j)\cos\theta_j)^2 = a_j\,((x-h_j)\cos\theta_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.2)}$$

Where controls the curvature, is the peak of the parabola and is the angle of rotation relative to the x-axis. In performing the preceding edge detection step, Wildes et al. bias the derivatives in the horizontal direction for detecting the eyelids, and in the vertical direction for detecting the outer circular boundary of the iris. The motivation for this is that the eyelids are usually horizontally aligned, and also the eyelid edge map will corrupt the circular iris boundary edge map if using all gradient data. Taking only the vertical gradients for locating the iris boundary will reduce influence of the eyelids when performing circular Hough transform, and not all of the edge pixels defining the circle are required for successful localisation. Not only does this make circle localisation more accurate, it also makes it more efficient, since there are less edge points to cast votes in the Hough space. There are a number of problems with the Hough transform method. First of all, it requires threshold values to be chosen for edge detection, and this may result in critical edge points being removed, resulting in failure to detect circles/arcs. Secondly, the Hough transform is computationally intensive due to its 'brute-force' approach, and thus may not be suitable for real time applications.

III) Masek Method

Masek introduced an open iris recognition system [3] for the verification of human iris uniqueness and also its performance as the biometrics. The iris recognition system consists of an automated segmentation system, which localize the iris region from an eye image and also isolate the eyelid, eyelash as well as the reflection regions. This Automatic segmentation was achieved through the utilization of the circular Hough transform in order to localize the iris as well as the pupil regions, and the linear Hough transform has been used for localizing the eyelid occlusion. Thresholding has been employed for isolating the eyelashes as well as the reflections. Now, the segmented iris region has got normalized in order to eliminate the dimensional inconsistencies between the iris regions. This was achieved by applying a version of Daugman's rubber sheet model, in which the iris is modeled as a flexible rubber sheet, which is unpacked into a rectangular block with constant polar dimensions. Ultimately, the iris features were encoded by convolving the normalized iris region with the 1D

Log-Gabor filters and phase quantizing the output to produce a bit-wise biometric template. For metric matching, the Hamming distance has been chosen, which provides a measure of number of disagreed bits between two templates.

III) Morphlogy and geometrical operations based segmentation

In this technique a global threshold is used to convert an RGB image to a binary digitized image that lies in the range [0, 1]. Principle of Otsu's method is used in global threshold function, which decides the threshold value to reduce the intraclass variance of black and white pixels. Median filtering is used to remove unwanted artifacts like “salt and pepper” noise. Instead of convolution, a median filter is used because it is more efficient than convolution when the target is to reduce noise without affected the edges. A morphological operation is employed to remove small object from the image.[4] This process removes from a binary image all connected components (objects) that have fewer than predefined value, producing another binary image. It removes background noise for perfectly track the pupil area. For iris boundary localization, the image is adjusted to find out boundary points on the iris-sclera border. Then two points are connected and draws two vertical lines from the middle of the radius. From the theory of geometry that the horizontal line from the middle of the radius in any circle passes through the centre of the circle. The intersection point represents the iris centre. Once they find the iris centre, they can easily determine the iris boundary. The find out parameters are the center coordinates (x, y) and the radius r .These parameters can easily form the circle equation. The best way of finding the radius (r) and center coordinates (x, y), is to find the edge points because it is very important to define the inner and outer circle accurately which is essential for iris area segmentation.

III. COMPARATIVE STUDY FOR LITERATURE SURVEY

Table 1 Comparative study for literature survey

TITLE	METHOD	PERFORMANCE	REMARKS
High confidence visual recognition of persons by a test of statistical independence	Integro-differential operator	High performance in iris recognition	Computational time is very high
Iris Recognition: An emerging biometric technology	Hough transform	Segmentation accuracy achieved up to an extent	Does not provide attention to reflections etc
Recognition of Human Iris Patterns for Biometric Identification	Liber Masek’s encoding algorithm	Localization of circular iris region as well as eyelids, eyelashes and also the reflections occurs	Speed of the system is low
Fast and Efficient Iris Segmentation Approach Based on Morphology and Geometry Operation	Morphology and geometrical operations	Its performance does not degradein case of seriously or partially affected eye images	Computational time is low.

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