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Recent Segmentation Techniques in Iris Recognition

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ABSTRACT:
Image segmentation is the fundamental step to analyze image and extract data from them in Iris recognition systems. The image segmentation is generally considering only certain region of interest from an image. A biometric framework offers automatic identification of a human being in view of the physical or behavioral features which is being used for identification or authorization of an individual. The various available segmentation methodologies which are available for verification and authentication are presented. The main importance is given to the segmentation step in the Iris recognition biometric system because it directly influences overall success or failure of Iris biometric methodology. In this survey paper, an introduction to biometrics and also a brief review of the segmentation methods that are used for iris recognition systems is presented.

Keywords: Biometric, Iris Segmentation, Feature extraction, Authentication, Normalization, Database.

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I. INTRODUCTION

"IRIS" referred to as a Biometric ancient civilizations trait of Egypt to Chaldea in Babylonia, China and also Greece believed in a divination concept called "Iridology", which deals with iris patterns of the eye. [1]There a famous olden day saying that "Eyes are the windows to know one's soul". Though the variation in iris patterns was observed and was suggested to be used for personal identification for the past one century, a practical or commercial iris detection paradigm was generated and patented by John Daughman, a computer scientist in 1989. [2]Identity verification and identification is becoming increasingly popular. Initially fingerprint, voice and face have been the main biometrics used to distinguish individuals. However, advances in the field have expanded the options to include other biometrics such as iris, retina, ear, vein, gait, smell and more. Among the large set of options, it has been shown that the Iris (Daughman, 2004) is the most accurate biometric. We aim at presenting the different segmentation methodologies with iris recognition.

1.1 Introduction to Biometrics:

Recognition and Authentication of an individual played a prominent role in past days as well as today, where so many inventions are carried on day by day because of its importance. Nowadays computers and electronic gadgets are highly extensively utilized and the considerable increase in the world‟s population and it is required to provide high-level authentication technology. Conventional methods like user id, passwords, ID cards, token-based systems cannot be prolonged for a long time and is safe enough in most of the security-based domains. The present community needs an instant and reliable authentication procedure [8]. Presenting the different biometric identification techniques that are existing in different platforms:

DNA Matching: The identification of an individual using the analysis of segments from DNA.
Ear biometric: The identification of an individual using the shape of the ear.
Eyes(Iris recognition): The use of the features found in the iris to identify an individual.
Eyes(Retina recognition): The use of patterns of veins in the back of the eye to accomplish recognition.
Face recognition: The analysis of facial features or patterns for the authentication or recognition of an individuals identity. Most face recognition systems either use eigen faces or local feature analysis.
Fingerprint recognition: The use of the ridges and valleys found on the surface tips of a human finger to identify an individual.

Gait: The use of an individuals walking style or gait to determine identity.
Hand Geometry recognition: The use of the [6] geometric features of the hand such as lengths of fingers and the width of the hand to identify an individual.
Signature recognition: The authentication of an individual by the analysis of handwriting style, in particular the signature.
Voice/Speech recognition: The use of the voice as a method of determining the identity of individual for access control.

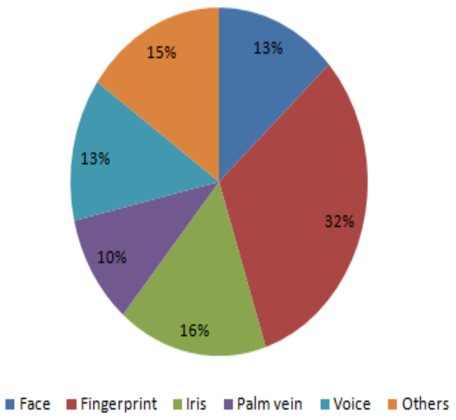

Fig. 1 Contribution of different biometric methods

In figure 1, the contribution of some of the physical/behavioral features used for authentication or authorization like face, fingerprint, Iris, palm vein, and voice. Though the Iris contribution in percentage is less than the fingerprint, iris includes more authentication and can be widely used easily in different platforms.

1.2 Anatomy of IRIS

Iris is the portion of the human eye. The human eye as appeared in Fig 2 is just about a spherical ball with a slight lump in the front part. Iris, is the best biometric attribute than different characteristics as these get modified with the [4]age and infections however iris pattern remains unaltered[5] for the duration of the life. Iris is gaining lot of attention of consideration because of its performance and quantifiable. Situated among cornea and eye lens, iris is inside ensured yet externally visible.

The iris comprises of particular characteristics such as the freckles, coronas, strips, furrows and so on. Extensive Research throughout the decade has expanded the reputation of iris. The issues with iris distinguishing reside in the structure of organ itself. Iris images caught are blocked by eyelids and eyelashes. The structure of iris and pupil isn't round and concentric. The iris boundaries are attempted to be circular, which prompts inappropriate localization of iris. Hence, powerful localization and normalization strategies are basic.

The Iris recognition method as biometric recognition was found in the early 1930s and patented since 1994. The method recognizes a human in the analysis of random and unique structures of iris. The color of iris and its structure are genetically inherited but not the texture of iris. Though genetically alike a human‟s iris is different and varies in shape. The iris is a muscle in an eye which adjusts the pupil size and manages the lighting entering into an eye. The color is because of the amount of melanin within the muscle. The structure will be formed before birth and from the year of one month, the texture remains stable throughout life. The single LED does not cause any damage while capturing iris, whereas more than one LED‟s if not carefully designed can cause damage to eyes.

Parts of eye:
The following is the image of an eye that was captured using the camera and includes the parts of the eye.

• **Upper eyelid and lower eyelid**: A slender crease of skin that spreads and secures the human eye.
• **Upper eyelashes and lower eyelashes:** The hairs at the edge of the eyelid. Shields the eye from garbage and are touchy to being contacted.
• **Sclera**: the white external layer of the eyeball. At the front of the eye, it is consistent with the cornea (straightforward layer framing the front of the eye).
• **Pupil:** The pupil is a gap situated in the focal point of the iris of the eye that enables light to strike the retina.
• **Retina**: Is the most profound, light-fragile layer or "coat" of shell tissue of the eye of most vertebrates and a couple of molecules. The optics of the eye make a drew in a two-dimensional image of the visual world on the retina, which makes an understanding of that image into electrical neural main impetuses to the brain to make the visual insight, the retina serving plenty of comparative limits as a film or a CCD in a camera
• **Medial/Lateral Canthus:** Is either corner of the eye where the upper and lower eyelids meet. All the more explicitly, the inward and external canthi are individual, the average and sidelong closures/points of the palpebral gap.
• **Iris:** Plural known as Irides or Irises is a slim, round structure in the eye, liable for controlling the breadth and size of the understudy and along these lines the measure of light arriving at the retina.

• **Collarette:** The rough hover in the mid-width of the iris, isolating the darker shade of the iris from the lighter shade of the iris.
• **Limbus:** The corneal limbus is the fringe of the cornea and sclera. It is a typical site for the event of corneal epithelial neoplasm.

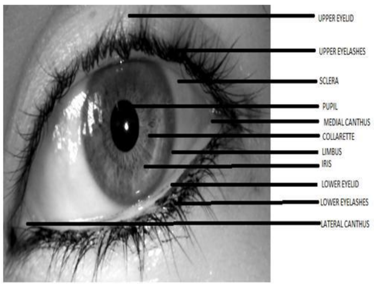

Fig 2: The human eye

II. IMPORTANCE OF IRIS RECOGNITION

The iris is the elastic, pigmented, connective tissue that controls the pupil. The iris is formed in early life in a process called morphogenesis where it begins to form during the third month of gestation (Kronfeld, 1962). The structures creating its striking patterns are developed in the eight month (Wolff, 1948), although pigment accretion may continue into the first postnatal years. Once fully formed, the texture is stable throughout life while the pattern becomes permanent after puberty. The iris of the eye has a unique pattern, from eye to eye and person to person. Each iris is a meshwork of melanocyte and fibroblast cells (Johnston, 1992).

2.1Characteristics of Iris:

Iris: a near ideal biometric
- ❑ highly unique
- ❑ stable over lifetime
- ❑ Protected internal organ
- ❑ Non invasive(easy to acquire)

Robust Recognition
- ❑ templates easy to store/encode
- ❑ fast and accurate matching algorithms

Security
- ❑ very low false accepts
- ❑ difficult to spoof

These days security is one of the critical factors in the field of information, business, and online business, military and so forth. Consequently personal identification has turned into a critical topic [5]. Iris deals in identification of individual in light of their physiological attributes. Moreover the quality, all-inclusiveness, permanence, collect-ability and novel data estimated in a solitary iris are considerably more noteworthy than other biometric data. Utilization of iris biometrics innovation include: identification cards and passports, border control and other government programs, jail security, database access and PC login, schools, aeronautics security, clinic security, controlling access to confined regions, going into to structures and houses[5]. Iris acknowledgment is utilized in prisons for the acknowledgment of detainees. Air terminals in different countries utilize iris recognition at their visitors and immigration control [5].

III. IRIS RECOGNITION SYSTEM

The iris recognition system working is demonstrated in phases like image acquisition, preprocessing, segmentation, Normalization and feature extraction.

3.1 Image acquisition

Image acquisition is the action of retrieving an image from source, usually a hardware based source, which can be used whatever processes need to occur afterward. In short, it is nothing but to capture the image by using hardware. In iris recognition process the first step is image acquisition. This step is very complicated because the size and color of iris of every person is different. The acquisition distance for average capturing is 2 to 3 feet and the average time is 1 to 2 seconds.

3.2 Segmentation

This step plays an important role in Iris recognition systems. During acquisition[16] of eye, image does not only contain iris but it also contains pupil and data derived from the surrounding eye region like sclera, eyelid and eyelashes as shown in Figure 2. Therefore, it is extremely important to segment and localize the iris from the acquired eye image, prior to Normalization or feature extraction. Iris localization is a process to isolate the iris region from the rest of the acquired image. Iris can be approximated by two circles, one for iris/sclera boundary and another for iris/pupil boundary. Localization & Segmentationinvolves three process such as 1) Pre processing 2) Inner Boundary Detection (iris-pupil) 3) Outer Boundary Detection (sclera-iris).

3.3 Normalization

Once the iris region is successfully[17] segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. Iris normalization converts iris image from Cartesian coordinates to Polar coordinates. The normalized iris image is a rectangle image with angular resolution and radial resolution.

3.4 Feature extraction

Feature extraction uses texture analysis method to extract features from the normalized iris image. The significant features of the iris are extracted for accurate identification purpose. the features of the iris is stored as digitized pattern 512 bytes record(half for features remaining half for comparison process).

3.5 Image recognition

This step performs two operations which are enrolment and authentication. Enrolment processes add the iris normalized binary form to the database. The authentication process takes the binary pattern and is compared with the database for its presence if it is identified then authentication is done.

Workflow of the Iris Recognition System

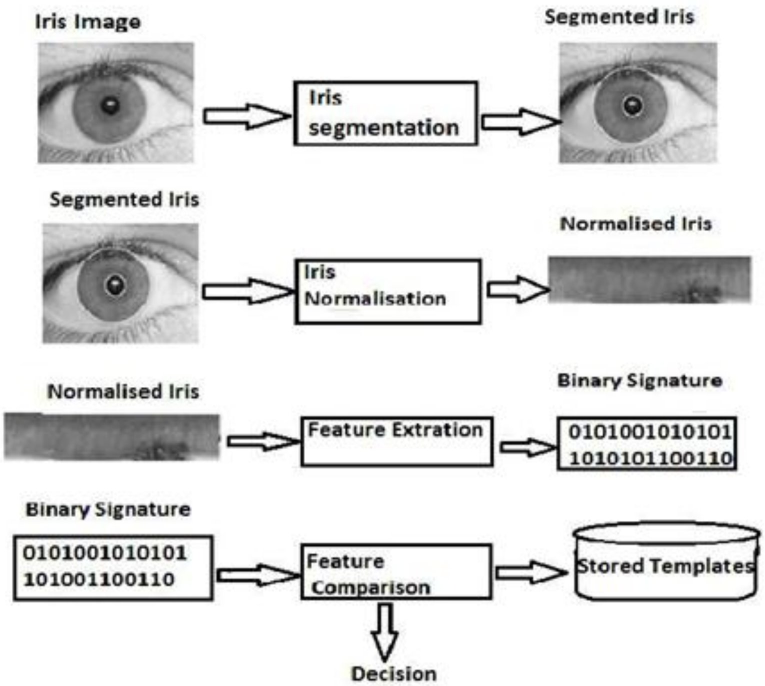

Fig 3: Iris Recognition process

The above diagram explains how the Iris recognition biometric system works which mainly depends upon the segmentation and normalization phases.

IV. LITERATURE SURVEY ON EXISTING IRIS SEGMENTATION TECHNIQUES

4.1 Introduction to image segmentation

Image segmentation means extracting an portion from an image which plays a crucial role for different application areas which can be called as region of interest (ROI). Image segmentation is mainly classified into four categories based on edge detection, threshold, region theory and model. Further edge detection process includes gray histogram technique uses Guassian curves, Gradient based method uses sobel operator, Canny operator, Laplacian operator, Laplacian of Guassian operators. In threshold method again contains global thresholding uses Otsu method, entropy based thresholding etc., and Local Thresholding uses simple statistical thresholding, 2-D entropy-based thresholding and histrogram transformation thresholding etc. Region based segmentation methods include region growing, region splitting and merging and theory based segmentation includes hard clustering, fuzzy clustering and neural network based segmentation. And the model based segmentation is applicable only when the exact shape is known.

4.2 The review of iris segmentation techniques

The study tells there are two major approaches: Daugman'sintegro-differential operator and Hough's transform-based. Nearly all existing methodologies use one of these two or their variants for segmentation.

4.2.1 **An integrodifferential operator** is proposed for locating the inner and outer boundaries of an iris by John Daughman. The operator assumes that pupil and limbus are circular contours and performs as a circular edge detector. Detecting the upper and lower eyelids is also performed using the Integro-differential operator by adjusting the contour search from circular to a designed accurate [2]. Integro-differential operator is defined as:

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

where $G_\sigma(r)$ represents a smoothing-function (e.g., Gaussian-filter) with scale σ. The symbol * represents the convolution operator. This operator searches over the entire image domain (x, y) to find the maximum blurred partial-derivative with respect to increasing radius r of the normalized contour integral of input eyeimage I(x, y) along a circular arc ds centered at (x_0, y_0,r). Here, r and (x_0, y_0,) denote the radius and center of the circular arc, respectively. the Integro-differential operator behaves as a circular edge detector. It searches for the gradient maxima over a 3D parameter space, so there are no threshold parameters required as in the Canny edge detector. Daugman simply excludes the upper and lower most portions of the image where eyelid occlusion is expected to occur. For upper and lower eyelids detection, the path of contour integration is modified from circular to parabolic curve. The operator is accurate because it searches over the image domain for the global maximum. It can compute faster because it uses the first derivative information.

4.2.2 **Hough transform** to localize iris boundaries [9]. Wildes' system models the eyelids as parabolic arcs. The upper and lower eyelids are detected by using a Hough transform based approach. The only difference is that it votes for parabolic arcs instead of circles. One weak point of the edge detection and Hough transform approach is the use of thresholds in edge detection. Different settings of threshold values may result in different edges that in turn affect the Hough transform result significantly. Since the inner and outer boundaries of an iris can be modeled as circles, circular Hough transform is used to localize the iris [18]-[21]. Firstly, edge detector is applied to a gray scale iris image to generate the edge map. The edge map is obtained by calculating the first derivative of intensity values and thresholding the results. Gaussian filter is applied to smooth the image to select the proper scale of edge analysis. The voting procedure is realized using Hough transform in order to search for the desired contour from the edge map. Assuming a circle with center coordinate (x_c,y_c) and radius r, each edge point on the circle casts a vote in Hough space. The center coordinate and radius of the circle with maximum number of votes is defined as the contour of interest. For eyelids detection, the contour is defined using parabolic curve parameter instead of the circle parameter. The disadvantage of Hough transform algorithm is that it is computationally intensive and therefore not suitable for real time applications. It requires a threshold value to generate the edge map. The selected threshold value may remove some critical edge points and result in false circle detection.

$$(x-x_c)^2 + (y-y_c)^2 = r2$$

4.2.3 Circular Hough Transformation (CHT)

Circular Hough Transformation is really an adjusted variant of Hough transform. In this strategy Hough transform joins with canny edge detector. Richard Duda and Peter Hart expands the General Hough Transform in1972 as Circular Hough Transform (CHT), is utilized to detect circles. The In Generalized Hough Transform. edge distinguished from the Canny edge detector forms the contribution to extricate the circle utilizing the Circular Hough Transform[9].The general Hough transform can be utilized to identify geometric shapes that can be composed in parametric shape for example lines, circles, parabolas, and hyperbolas. The circular Hough Image Acquisition Iris Segmentation iris Iris Normalization Feature Encoding Matching International Journal of Computer Applications (0975 – 8887) Volume 182 – No. 24, October 2018 54 transform can be utilized to identify the circles of a known radius in an image. The transform is processed by drawing circles of a given radius at each point in the edge image. For each point where the perimeter of a drawn circle passes, the coordinate was augmented by 1. This was improved the situation each circle drawn to make an accumulation array. A circle is shown by peaks in the accumulation array (Hough space) [3].Detection of circle utilizing this transformation requires learning of the radius. [10]

4.2.4 Circular Gabor filters

In the spatial frequency domain, we can extract the information of an image at a certain scale and at a certain orientation by using some specific filters, such as multichannel Gabor filters [6][9]. In recent years, Gabor filter based methods have been widely used in computer vision, especially for texture analysis. Gabor elementary functions are Gaussian modulated by oriented complex sinusoidal functions.

4.2.5 **Discrete circular active contour:**

Active contour model has been used to localize iris [22], [23]. The contour is defined as a set of n vertices connected as a simple closed curve. The movement of the contour is caused by internal and external forces acting on the vertices. The internal forces expand the contour into a Iris Image Capture Image Preprocessing Feature Extraction Template Matching Authentic/ Imposter 978-1-4244-2328-6/08/$25.00 © 2008 IEEE perfect circle. The external forces push the contour inward. The contour moves under the influence of the internal and external forces until it reaches equilibrium. The average radius and center of the contour obtained are the parameters of the iris boundary. The discrete circular active contour search for the iris boundary is affected by the specular reflections from the cornea. Therefore, image preprocessing algorithm is required to remove the specular reflections.

4.2.6 Bisection method: In both [24] and [25], the bisection method is used to locate the center of the pupil. The center of the pupil is used as reference to detect the inner and outer boundaries of the iris. Firstly, edge detection is applied to the iris image to extract the edge information. For every two points on the same edge component, bisection method is applied to draw the perpendicular lines to the center point. The center point with maximum number of line intersections is selected as the center of the pupil. A virtual circle is drawn with reference to the center of the pupil and the radius is increased within a certain range. Two virtual circles with the largest number of edge points are chosen as the inner and outer boundaries of the iris. Bisection method is affected by the non-uniform illuminations and glasses reflections. As a result, the iris inner boundary cannot be localized accurately. Similar to the discrete circular active contour method, image preprocessing algorithm is needed to remove the high intensity areas caused by illuminations and reflections.

4.2.7 Black hole search method: Black hole search method is used to compute the center and area of a pupil [23], [25]. Since the pupil is the darkest region in the image, this approach applies threshold segmentation method to find the region. Firstly, a threshold is defined to identify the dark areas in the iris image. The dark areas are called as “black holes”. The center of mass of these black holes is computed from the global image. The area of pupil is the total number of those black holes within the region. The radius of the pupil can be calculated from the circle area formula. Black hole search method is not suitable for iris image with dark iris. The dark iris area would be detected instead of the area of pupil.

4.2.8 Canny edge Detection: The Canny Edge detection method is used to discover the iris and pupil boundaries from the caught image. This gives the effective edges of eye. So we can get the correct pupil edge to recognize the image. The algorithm keeps running in 5 separate steps: They are Smoothing, Finding gradients, Nonmaximum suppression, Double thresholding, Edge following by hysteresis [25]. The primary point of smoothing is to remove the noise from the obscure images. At the point when the grayscale intensity of the image is changed to discover the edges essentially canny algorithm is utilized. Those regions are found by deciding gradients of that image. From the smoothed images the gradient points are decides every pixel. It is to change over the obscured edges in the image of the gradient magnitude to make sharp edges. Fundamentally this is finished by preserving all neighborhood maxima in the gradient image, and erasing everything else. The edge-pixels staying after the non-maximum suppression step are set apart with their quality pixel-by-pixel. Strong edges are translated as "specific edges", and can quickly be incorporated into the last edge image. Weak edges are incorporated if and only if they are associated with strong edges. Edge tracking can be executed by BLOB-investigation (Binary Large Object).

METHOD	CHARACTERISTICS	RESULT
Integro-differential operator	Performance is good for iris recognition using 2D Gabor filters	The time taken to locate iris is high
Image intensity gradient and Hough transform	Zero crossing and 1D signals	The system performance is decreased
Circular Hough transform and canny edge detector	2D gabor wavelets and Biorthogonal wavelet	FAR and FRR is so low.
Circular Gabor filters	Accuracy for both pupil and iris boundaries is possible	Overall accuracy is less than the unified framework approach
Circular Active Contours	Iris code is used	Gaze deviation has been evaluated, and time complexity is low
Integro-differential operator and angular deformation model	Independent component analysis	Works well for non-perfect dataset
Circular Hough Transform, Canny, Sobel and Prewitt edge	Feature vector from wavelet transformation and 1d gabor filter	Sobel edge detector demonstrates great execution in accuracy

detection		
Gray level information, Canny edge detection and Hough transform	1D real-valued feature vector using multichannel spatial filters	Generally moderate component extraction process

Table 1: Comparison table based on literature survey

V. CONCLUSION

This paper includes the introduction to Biometrics, applications, Iris recognition procedure. A brief description of each step is defined. Different segmentation methods are mentioned along with their specifications. A comparison table is composed of the segmentation methods along with characteristics and result is shown. These segmentation techniques and combination of these techniques can be used for the reliable identification system.

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