International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 1, Issue 2, February 2014)

Automated IRIS Localization using Active Contour Model for IRIS Recognition

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Abstract- **With the total population of the world marking 10^{10} millions, 'no two irises are same' makes the feature enriched iris pattern, the best among the biometric traits for authentication or identification of an individual. The success of recognition mainly depends on how accurately the iris portion is extracted from the acquired image, as it is the main source of data with which authentication or identification of an individual person is attained. The quest for segmenting the iris from the captured eye image accurately and precisely, took research to new heights as no. of researchers invented numerous methods to attain the task. Here in this paper we propose an automated method to segregate the iris portion using active contour model on the data base provided by CASIA-iris-1000.**

Key words: **Iris pattern, Euclidean distance, Active contour, CASIA, PMS**

I. INTRODUCTION

The growth of technology evolution brought wide range of changes in human day to day life. It made human survival a calk walk for many transactions. But at the dark side it also emphasizes the need of security in utilizing it. At the same time, very inception of digital technology has created a situation, that anything developed by technology can be duplicated or hacked. Fake ID, which is one of the most challenging problems in any part of the society, is threatening mankind in the events like terror attacks, cyber crime, and threat to properties etc, which are to be taken care of with highest priority. In the present scenario biometrics enabled access machine play vital role in producing accurate authentication for technology utilization, which avoids malfunction, fake IDs and create an ambiance of reliable security to human survival.

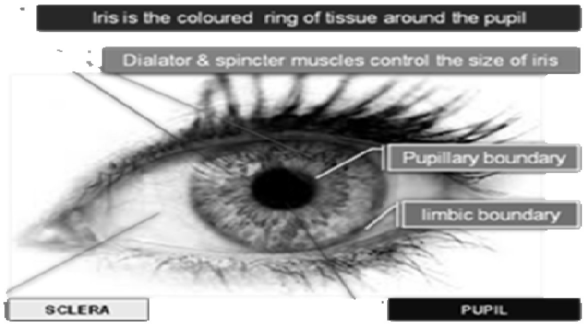


Fig.1: eye image

Biometrics is the science of recognizing the identity of a person based on the physical or behavioral attributes of the individual such as face, fingerprints, voice and iris. With the very prominent and distinctive need for robust human recognition techniques in critical applications such as secure access control, international border crossing and law enforcement, biometrics has positioned itself as a viable technology that can be integrated into large-scale identity management systems. Biometric systems operate under the premise that many of the physical or behavioral characteristics of humans are distinctive to an individual, and these attributes can be faithfully acquired via suitably designed sensors and represented in a numerical format that lends itself to automatic decision-making in the context of identity management. Face, finger prints, hand geometry, retina, voice, signature etc are some of the popular biometric traits used in the present scenario for personal identification.

Bio metrics gifted a new key which is more secure with more than 266 different features in its pattern for more accuracy, uniqueness and robustness, small area for extraction, non invasive for trouble free image capturing, well protected internal organ, which does not undergo changes almost for the life span, that is nothing but the IRIS PATTREN of an individual. IRIS recognition system has been playing sustainable role in recent cyber issues. It has become a dominant one among other bio metric systems such as finger prints and facial features.
This paper presents an automated segmentation algorithm to segregate the iris portion from the eye images taken from CASIA database [16] and compares the accuracy with other prominent algorithms.

II. IRIS STRUCTURE

The human eye, is an organ with a complex mechanism, producing vision to the human, looks spherical in structure with a radius of approximately 1.3 cms [1]. Basically eye structure can be decomposed into three layers.1.outer layer, 2.middle layer and 3.inner layer. The visible outer layer is composed of multilayered cornea and sclera connected through limbus. Middle layer consists of choroid, ciliary body and iris. Inner layer is the retina, which is sensitive to light and converts light into electrical impulses which were carried to brain through optical nerve. A chamber filled with vitreous humor known as vitreous chamber along with crystalline lens were accommodated within this layer. This lens is suspended flexibly to ciliary body through ligaments. Iris, visible as the colored ring inside the eye, separates cornea and crystalline lens into two chambers named as anterior chamber and posterior chamber which are filled with aqueous humour. The aqueous humor flows between these two chambers through pupil without any resistance.

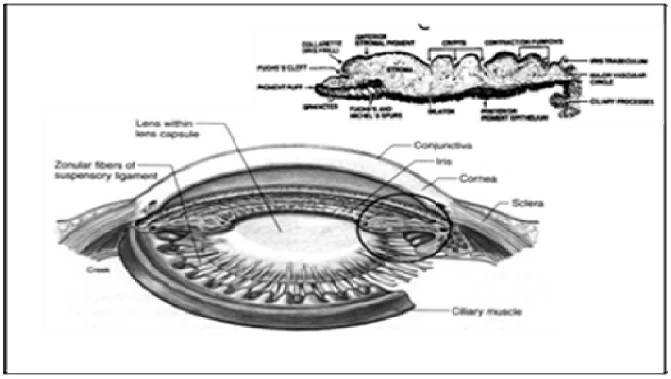


Fig.2: Anatomy of iris

Iris is made up of three layers called endothelium, stroma and epithelium. Endothelium is a thin layer of epithelial cells that interfaces blood vessels and lymphatic vessels. Stroma layer is made up of collagenous connective tissue. Stroma pigmentation plays an important role in determining the color of iris. Stroma is connected to sphincter muscles and dilator muscles. Sphincter muscles are useful to contract the pupil in circular motion and dilator muscles are useful in pulling iris radially to enlarge the pupil. Posterior to this there is heavily pigmented Epithelium layer which mainly restricts light entering to retina through iris. The anatomy of iris is shown in the fig-2.

The visible surface of iris extends between outer ciliary region at one end and inner pupillary region at the other end, with zigzag collarette in between. Collarette is the thickest region in the iris where sphincter and dilator muscles overlap one another. Crystalline lens acts as support base to the iris where as cornea covers it as a protective layer on the surface.

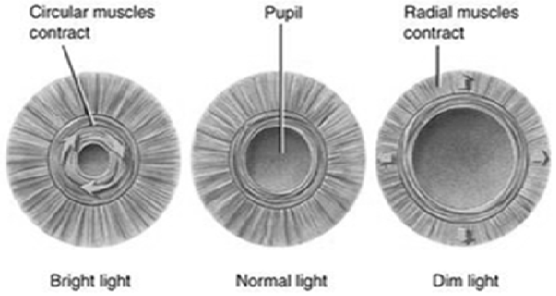


Fig.3: Pupil size variation to light

The darkest part in the visible eye is pupil, which is an opening that regulates the amount of light to enter into the retina. In brightly lit conditions pupil becomes miotic as circular sphincter muscles are pulled towards the centre, making pupil to constrict and reduces amount of light entering into retinal area. In dimly lit conditions it becomes my driatic as radial dilator muscles pulls away from the centre, making pupil dilate and tries to allow maximum light into retina as shown in the fig-3.

Iris pattern is rich with visible features such as freckles, filaments, cornea, stripes, furrows, crypts, arching elements, pigment frills, radial furrows, pupil controlling muscles, collarette etc. These randomly distributed irregularly shaped microstructures make the iris pattern unique for an individual and make it most reliable pattern for human recognition systems in biometrics.

III. IMPLEMENTATION:

First the idea of automated iris recognition was proposed by Flom and Safer [3]. Basically the image acquired from the camera contains complete eye region along with eyebrows, some part of nose, eye lids etc, which is not the real data required for us. As iris is the only region that has to be extracted and compared with other templates, it is compulsion to segregate iris portion from the acquired eye image, prior to performing iris matching. In Iris recognition system, the important works to be carried over are image acquisition, iris segmentation, feature extraction and recognition. Among all, the success rate of recognition highly depends on how accurately the iris part is extracted from the acquired eye image, as it is the main source of data to be used for further stages. In this regard accurate segmentation of iris is of prime priority.

So many methods and concepts were carried over to segment the iris portion by several researchers, among which Daugman's integro differential operator [4], Wilde's binary edge construction with circular Hough transform [5] took top places. W. Boles, B. Boashash [7], W. K Kong and D. Zhang [8], Li Ma, Tieniu Tan, Yunhong Wang, and Dexin Zhang [9] also gave some of the best algorithms for segmentation process. Though the above said algorithms were accurate in separating the iris portion, they were logged with some draw backs.

Masek's approach [10] is one of the bench mark algorithms, available to the researchers for localizing the iris region which uses hough transform for detection of both limbiac boundary as well as pupillary boundary.

Hough transform needs very large data and takes number of iterations in finding the circular portions of pupil as well as iris. The computations required becomes hazardous, resulting in reduced speed for real time applications. It requires threshold values to be set for edge detection. some times because of this some edge points may be removed resulting in failure to detect circles. Many of the approaches described have disadvantage of putting thresholds for edge detection, decreasing the robustness of image intensity changes. S. P. Narote , A. S. Narote , L. M. Waghmare[14] proposed automated segmentation algorithm which is applied on cassia v1 database where pupil region is processed and put in the database without specular reflections so that pupil region can be segmented easily for further processing in iris localization.

Here we propose an algorithm for segmentation of iris from the eye image, which takes care of determining pupilary boundary, limbiac boundary and eliminating unwanted information . The various stages required to segment iris is shown in the flow chart shown in fig-4.

Image intensity balance: The dark pupil can be segregated easily, based on intensity information from the reasonable quality of eye image. The gray levels of pixels in pupil region will be close to the darkest pixels in an image. The specular reflections created by LED lighting, to illuminate eye, can also be removed easily as they were very small when compared to the size of the pupil. Assuming short stand-off distances and cooperative users, the location of pupil may always be near to the centre of the image. so other dark regions at the corners and at remaining locations can be removed with an ease.

All the images acquired from camera may not have same average intensities. As a result the minimum pixel value and maximum pixel values in different images may be different. So it becomes difficult to apply same algorithm for all the images which are going to yield unsatisfactory results. Minimum pixel value may differ from one image to other image. Particularly in the process of segmentation of pupil part which is going to contain darkest black pixels, all the images we are using in the data base may not possess the same minimum pixel value. So we thought of putting a threshold value for no. of black pixels available in the image, which are mainly contributing for pupil area, and if the no. is below the threshold, their quantity may be enhanced.

In order to claim the number of dark pixels we took the help of histogram, which gives information of no. of pixels vs gray scale intensity. If the number of dark pixels is below the threshold, all the gray pixel values of the image are subtracted by certain value appropriately to increase the population of dark pixels. To identify the pupil region in the image, we approximated a threshold value of 10 . Some times as the intensity of image is very low, a very few no. of pixel are available in this region, contributing for pupil part. So in order to enhance the density of dark pixels, all the pixel values of image are subtracted with a value 10. After dark pixels enhancement the image is resized to one fourth of the original image.

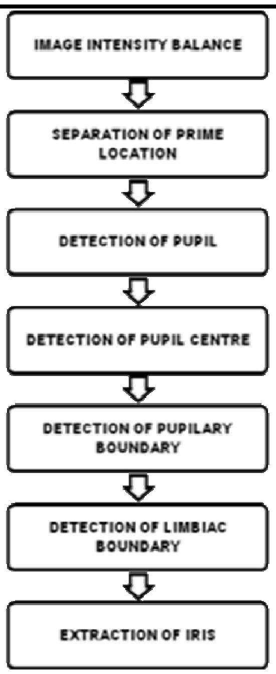


Fig. 4: Process chart for iris localization

Segmentation of prime location: In the process of acquisition of the iris images the light is mainly focused at the iris region, and as the illumination is on iris, the illumination will deminish as it moves away from the iris region to the corners. i.e. the corners of the image will be much darker when compared to the centre of the image. These dark pixels at corners are big obstacles as noise, in the separation of the pupil part from the image. So a circular contour is formed around the iris to eliminate this unwanted portion of the eye in such a way that the portion within the circle will contain the same original image pixels and outside region will be set to gray value of 255. The diameter of this circular contour is selected in such a way that the complete pupil part will be inside the circle. The selection of diameter of this circular contour is most important as it should be common for all the images.

Detection of pupil region: The Euclidean distance from the centre of the image to each and every pixel of the image is computed and stored. With the image centre as centre, the image is scanned circularly with radius ranging from 1 to radius of contour circle, in the incremental way. With an appropriate threshold value, the image is binarized to extract dark black pixels (0) which are contributing for the pupil part and making all the remaining pixels to white (255). The connecting components with pupil region and noisy pixels inside the pupilary region are eliminated by using appropriate morphological operators.

Detection of pupil centre: Once the pupil part is completely extracted, now it is the time to find the centre of pupil. This can be computed by taking the mean of the rows and columns of the binary image. The lowest of mean of the rows gives the x-coordinate of the pupil where as the lowest of mean of the columns provide the y-coordinate of the pupils' centre.

Defining pupillary boundary: After finding the centre of the pupil, the radius of pupil region can be obtained as fallows. The binarized image is summed in x and y directions to find x-vector and y-vector and after summation the non zero values of x-vector and y-vector are made 1. Summing x-vector and dividing it by 2 will give the radius PR of pupilary boundary. Thus with a radius PR, a circle is drawn with (xc,yc) as centre, to segment the pupil region and at the same time defining the pupilary boundary also.

Defining limbiac boundary: Now it is the time to locate the limbiac boundary, so that the iris region can be extracted completely by separating it from the sclera and pupil regions. An integro differential operator is used for this purpose.

$$\max(r\ ,x_0,y_0)=\left|M(r)*\frac{\partial}{\partial r}\left[\oint_{(r\ ,x_0,y_0)}\frac{I(x.y)}{2\pi r}ds\right]\right|$$

The operator behaves as circular edge detector, that searches iteratively for maximum contour integral derivative with increasing radius at successively finer scales of analysis through the three parameter space of center and radius (xc,yc,r) defining the path of the contour integration. In implementation, the contour fitting procedure is discretised, with finite differences serving for derivatives and mean is used to instantiate integrals and convolutions.
generally, fitting contours to images by using this type of optimization formulation is a standard machine vision technique, often referred to as Active Contour Modelling.

For determining the limbus boundary, we use the principle of maximum difference between mean gray level of succeeding circumferences as edge detection algorithm. First the mean of pixels on each circle are computed, by incrementing the radius, from the centre of the pupil and a vector is formed with these mean values. The mean of gray levels of all the pixels on a circumference of a circle with a radius (r) is denoted by m1 and that of radius (r+1) is denoted by m2,and so on. To detect the limbiac boundary these values are smoothed with POST MEAN SUBSTITUTION (PMS) (present value replaced with mean of post values). This function brings maximum values of blur at transitions of boundaries. The maximum value of the blur above the pupilary radius value gives the limbiac boundary and radius of limbiac boundary (IR) from centre of pupil is determined. Once the limbiac boundary is determined, the iris part between limbiac and pupilary boundaries is extracted marking all the remaining pixel values to gray value 255 (white).

Here we are assuming that pupil and iris are circular in shape and share the same centre. The located iris region and segmented iris images are shown in fig 5(a),5(b)

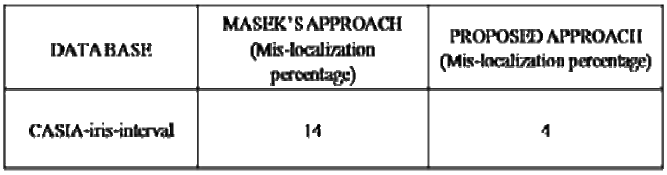

PUPIL LIMBIAC BOUNDARIES
SEGMENTED IRIS REGION

Fig-5(a),5(b)

IV. EXPERIMENTAL RESULTS:

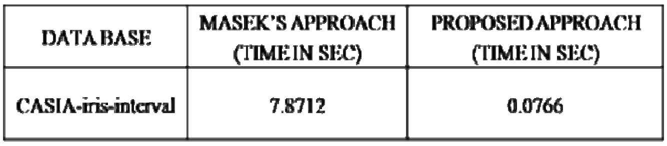
A set of 50 iris images are taken from the cassia-iris-interval for comparison of proposed approach with Masek's approach. Personal computer 2.81GHz ,i3 processor with 2GB RAM is used for experimenting the proposed segmentation algorithms using MATLAB-8.0.

The results are tabulated as below



DATABASE	MASEK'S APPROACH (Mis-localization percentage)	PROPOSED APPROACH (Mis-localization percentage)
CASIA-iris-interval	14	4

Table-1: Iris mis localization results



DATABASE	MASEK'S APPROACH (TIME IN SEC)	PROPOSED APPROACH (TIME IN SEC)
CASIA-iris-interval	7.8712	0.0766

Table-2: segmentation time results

From the table it can be observed that the proposed approach gives much better segmentation in comparison with Masek's algorithm. Especially the average time taken to segment the iris was enormously reduced, nearly 100 times to that of its counterpart, which is the main achievement of the proposed algorithm.

V. CONCLUSION:

The automated iris localization using active contour model is a straight forward segmentation method used for segregating the iris part from the eye image ,produced reasonable accuracy and efficiency when compared to the bench mark algorithm presented by masek. The proposed algorithm was applied on cassia-iris-interval database and results were compared.

Masek’s approach failed where the intensity of images are low. It localizes the pupilary boundary more accurately than limbiac boundary. But the accuracy of detecting boundaries is reasonably high in comparison with the proposed algorithm.

VI. ACKNOWLEDGEMENTS:

Libor Masek, Peter Kovesi. MATLAB Source Code for a Biometric Identification System Based on Iris Patterns, The School of Computer Science and Software Engineering, The University of Western Australia. 2003, is used for comparison of segmentation of masek’s approach with our proposed algorithm. we express our sincere gratitude to them. We are very thankful to Chinese Academy of Sciences Institute of Automation, for providing casia-iris-interval database.

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