IMPROVING EFFECTIVENESS IN IRIS LOCALIZATION USING ACTIVE CONTOURS WITH LESS COMPUTATIONAL TIME

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ABSTRACT

Human identification through iris recognition has been acknowledged as one of the most accurate biometric modalities because of its high recognition rate. Generally, the process of iris recognition consists of six subcomponents, viz. iris localization, iris segmentation, normalization, iris feature extraction, and matching.In order to provide successful iris recognition, iris localization plays a major role. In the present study, we compare Daugman, Wildes and Cui and R P Ramkumar methods for Iris localization. The most difficult part in iris identification system is the iris localization. The iris is the colorful part of the eye that surrounds the pupil; it defines the inner and outer boundaries of iris region used for feature analysis. Several researches have been made in the subject of segmentation and iris finding. The efficiency of the algorithms can be increased if the inner boundary and outer boundary of iris are detected accurately and also the computational cost will be reduced. This paper mainly focuses on iris localization process. Section 2 deals with overview of existing iris localization Algorithms and their comparison. Then Section 3 insists on the proposed method. In this proposed iris localization method, a segmentation techniques is used based on active contours which is 100% accurate compared to Daugman, s integro-differential method. For iris outer boundary detection, contrast enhancement, special wedges, and thresholding are employed to detect the specific iris regions from an eye image, which is capable of almost completely eliminating the geometry-based distortion of defected iris data for any human subject.

KEYWORDS- *Iris recognition, Iris localization, Iris segmentation, Active contours, Computational time*

I. INTRODUCTION

Iridology practitioners examine the iris to determine possible problems with the rest of the body. Iridology isn't used to diagnose any specific disease; but it can be used to discover possible vulnerabilities or weaknesses in all major organs of the body, including the heart, lungs, brain and kidneys. Biometrics refers to the identification and verification of human identity based on certain physiological traits of a person. The commonly used biometric features include speech, fingerprint, face, handwriting, gait and hand geometry etc. The face and speech techniques have been used for over 25 years, while iris method is a newly emergent technique.

In the evaluation of human-computer interfaces, an increasing number of researchers conducted on analyses of users' eye movements during task completion [1]. Gaze trajectories indicate difficulties that users encounter with certain parts of the interface and point out inappropriate spatial arrangement of interface components. However, when performing such studies, scientists often neglect the analysis of another variable that they receive as a "product" of video-based eye tracking, namely the size of the user's iris and pupil.

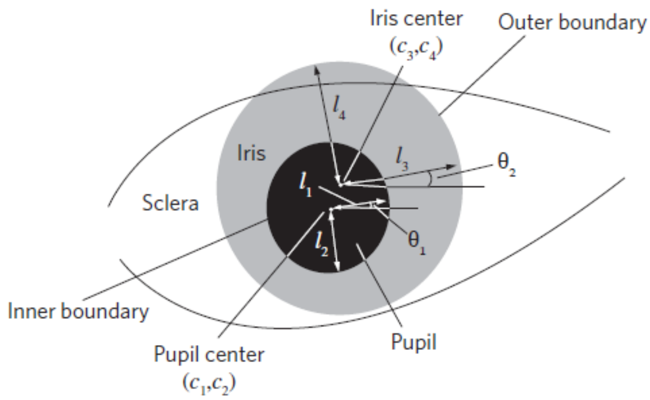


Fig. 1. Iris image with typical elements labeled.

The iris is the colored part of the eye behind the eyelids, and in front of the lens. It is the only internal organ of the body which is normally externally visible. These visible patterns are unique to all individuals and it has been found that the probability of finding two individuals with identical iris patterns is almost zero. Though, there lies a problem in capturing the image, the pattern variability and the stability over time, makes this a reliable security recognition system.
Biometrics is the automated use of physiological or behavioral characteristics to determine or verify identity. Biometric authentication requires only a few seconds and biometric systems are able to compare thousands of records per second. Finger-scan, facial-scan, iris-scan, hand-scan and retina-scan are considered physiological biometrics and voice-scan. Signature-scan is considered as behavioral biometrics. A distinction may be drawn between an individual and an identity, the individual is singular, but he may have more than one identity, for example ten registered fingerprints are viewed as ten different identities.
The combinatorial complexity of phase information across different iris textures from persons spans around 249 degrees of freedom and generates discrimination entropy of about 3.2 bits/mm^2 over the iris, enabling decisions about personal identity with extremely high confidence. The extracted feature is the phase characteristic of the picture element in study, related to adjacent ones, in an infrared (not color) iris photograph. This means, for example, that false match probabilities might be as low as one in 1074. False reject rates may be as high as 5–10% depending on ambient conditions, so scientific tests should be done under ideal conditions to minimize chance for errors [2].

II. RELATED WORK

In this research paper [3], Algorithms developed by the author for recognizing persons by their iris patterns have now been tested in many field and laboratory trials, producing no false matches in several million comparison tests. The recognition principle is the failure of a test of statistical independence on iris phase structure encoded by multi-scale quadrature wavelets. The combinatorial complexity of this phase information across different persons spans about 249 degrees of freedom and generates a discrimination entropy of about 3.2 b mm2 over the iris, enabling real-time decisions about personal identity with extremely high confidence. The high confidence levels are important because they allow very large databases to be searched exhaustively (one-to-many “identification mode”) without making false matches, despite so many chances. Biometrics that lack this property can only survive one-to-one (“verification”) or few comparisons. This paper explains the iris recognition algorithms and presents results of 9.1 million comparisons among eye images from trials in Britain, the USA, Japan, and Korea.
This paper [4], examines automated iris recognition as a biometrically based technology for personal identification and verification. The motivation for this endeavour stems from the observation that the human iris provides a particularly interesting structure on which to base a technology for non-invasive biometric assessment. In particular, the biomedical literature suggests that irises are as distinct as fingerprints or patterns of retinal blood vessels. Further, since the iris is an overt body, its appearance is amenable to remote examination with the aid of a machine vision system. The body of this paper

details issues in the design and operation of such systems. For the sake of illustration, extant systems are described in some amount of detail.

In this research paper [5], with the development of the current networked society, personal identification based on biometrics has received more and more attention. Iris recognition has a satisfying performance due to its high reliability and non-invasion. In an iris recognition system, pre-processing, especially iris localization plays a very important role. The speed and performance of an iris recognition system is crucial and it is limited by the results of iris localization to a great extent. Iris localization includes finding the iris boundaries (inner and outer) and the eyelids (lower and upper). In this paper, we propose an iris localization algorithm based on texture segmentation. First, we use the information of low frequency of wavelet transform of the iris image for pupil segmentation and localize the iris with a differential integral operator. Then the upper eyelid edge is detected after eyelash is segmented. Finally, the lower eyelid is localized using parabolic curve fitting based on gray value segmentation. Extensive experimental results show that the algorithm has satisfying performance and good robustness.

III. PROPOSED METHODS

A. Proposed Technique of Daugman:-

1) Finding an IRIS in an image:

To capture the rich details of iris patterns, Monochrome CCD cameras (480*640) have been used because NIR illumination in the 700–900-nm band was required for imaging to be uninstructive to humans. Images passing a minimum focus criterion are then analyzed to find the iris, with precise localization of its boundaries. Although the results of the iris search greatly constrain the pupil search and generally the pupil center is nasal, and inferior, to the iris center.

Thus, all three parameters defining the pupillary circle must be estimated separately from those of the iris. A very effective integro-differential operator for determining these parameters is

$$\max_{r,x_0,y_0}\left|G_\sigma(r)*\frac{\partial}{\partial r}\oint_{r,x_0,y_0}\frac{I(x,y)}{2\pi r}\,ds\right|$$

Where I(x, y) is an image such as Fig. 1 containing an eye. The operator searches over the image domain (x, y) for the maximum in the blurred partial derivative with respect to increasing radius, of the normalized contour integral I(x, y) of along a circular arc ds of radius and center coordinates (x_0, y_0). The symbol denotes convolution and Gσr is a smoothing function such as a Gaussian of scale. The complete operator behaves as a circular edge detector, blurred at a scale set by σ .

The operator in (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. 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.

2) IRIS Feature Encoding by 2-D wabelet demodulation:

Each isolated iris pattern is then demodulated to extract its phase information using quadrature 2-D Gabor-wavelets [6], [7]. This encoding process is illustrated in Fig. 2.

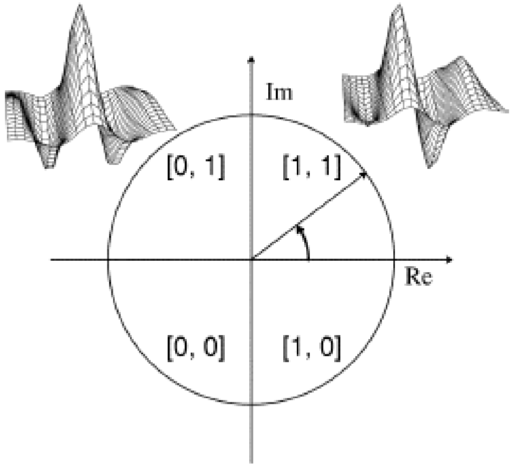


Fig 2. The phase demodulation process used to encode iris patterns.

A desirable feature of the phase code portrayed in Fig. 2 is that it is a cyclic, or gray code: in rotating between any adjacent phase quadrants, only a single bit changes, unlike a binary code in which two bits may change, making some errors arbitrarily more costly than others. Altogether, 2048 such phase bits (256 bytes) are computed for each iris, but in a major improvement over the author's earlier [8] algorithms.

Only phase information is used for recognizing irises because amplitude information is not very discriminating.

3) The test of statisitical indpendence of phase sequences:

The key to iris recognition is the failure of a test of statistical independence, which involves so many degrees-of-freedom that this test is virtually guaranteed to be passed whenever the phase codes for two different eyes are compared, but to be uniquely failed when any eye's phase code is compared with another version of itself.

The test of statistical independence is implemented by the simple Boolean Exclusive-OR operator (XOR) applied to the 2048 bit phase vectors that encode any two iris patterns, masked (AND'ed) by both of their corresponding mask bit vectors to prevent non iris artifacts from influencing iris comparisons. The XOR operator detects disagreement between any corresponding pair of bits, while the AND operator ensures that the compared bits are both deemed to have been uncorrupted by eyelashes, eyelids, specular reflections, or other noise. The norms ( ) of the resultant bit vector and of the AND'ed mask vectors are then measured in order to compute a fractional. Hamming Distance (HD) as the measure of the dissimilarity between any two irises, whose two phase code bit vectors are denoted {codeA, codeB} and whose mask bit vectors are denoted {maskA, maskB}:

$$HD = \frac{\left\| (codeA \otimes codeB) \cap maskA \cap maskB \right\|}{\left\| maskA \cap maskB \right\|}$$

The Boolean operator's ∩ and convolution are applied in vector form to binary strings of length up to the word length of the CPU, as a single machine instruction. Thus, for example on an ordinary 32-b machine, any two integers between 0 and 4 billion can be XOR'ed in a single machine instruction to generate a third such integer, each of whose bits in a binary expansion is the XOR of the corresponding pair of bits of the original two integers.

B. Proposed Technique of Wildes:-

1) Image Acquisition :

One of the major challenges of automated iris recognition is to capture a high-quality image of the iris. The Daugman system captures images with the iris diameter typically between 100 and 200 pixels from a distance of 15-46 cm using a 330-mm lens. Similarly, the Wildes et al. system images the iris with approximately 256 pixels across the diameter from 20 cm using an 80-mm lens.

For illumination of iris, Daugman uses an LED-based point light source in conjunction with a standard video camera. This results in a particularly simple and compact system. Further, by careful positioning the light source below the operator, reflections of the point source off eyeglasses can be avoided in the imaged iris whereas Wildes uses, diffuse source and polarization in conjunction with a low-light level camera. This results in an illumination rig that is more complex, but has certain advantages. First, the use of matched circular polarizers at the light source and the camera essentially eliminates the specular reflection of the light source. Second this allows for more of the iris detail to be available for subsequent processing. Both the Daugman and Wildes et al. systems require the operator to self-position his eye region in front of the camera. Daugman's system provides the operator with live video feedback via a miniature liquid crystal display placed in line with the camera's optics via a beam splitter. This allows the operator to see what the camera is capturing and to adjust his position accordingly.

2) Iris Localization:

It is important to localize that portion of the acquired image that corresponds to an iris. With reference to how the Daugman and Wildes et a/., iris recognition systems performs iris localization which further illustrates the issues. Both of these systems make use of first derivatives of image intensity to signal the location of edges that correspond to the borders of the iris.

The two systems differ mostly in the way that they search their parameter spaces to fit the contour models to the image information.

To understand how these searches proceed, let I(x, y) represent the image intensity value at location (x, y) and let circular contours (for the limbic and papillary boundaries) be parameterized by center location (x_c. y_c) and radius r. The Daugman system fits the circular contours via gradient ascent on the parameters (x_c. y_c, r) so as to Maximize,

$$\left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right|$$

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 a that smooth's the image to select the spatial scale of edges under consideration, In implementation, the contour fitting procedure is discretized, with finite differences serving for derivatives and summation used to instantiate integrals and convolutions.

Both approaches of localizing the iris have proven to be successful in the targeted application.

3) Pattern Matching:

The final task is to decide if this pattern matches a previously stored iris pattern. This matter of pattern matching can be decomposed into four parts:

1) Bringing the newly acquired iris pattern into spatial alignment with a candidate data base entry.
2) Choosing a representation of the aligned iris patterns that makes their distinctive patterns apparent.
3) Evaluating the goodness of match between the newly acquired and data base representations.
4) Deciding if the newly acquired data and the data base entry were derived from the same iris based on the goodness of match.

C. Proposed Technique of Cui:-

Author has mentioned above that pre-processing, especially iris localization is very important for an iris recognition system. They want to find the visible part of iris to obtain the feature vector, so iris localization includes not only locating the inner and outer circular boundary of iris, but also detecting the eyelids. However, eyelid detection is relatively difficult due to the low SNR (signal-noise ratio) in upper eyelid area which is discussed below. They select an easy-to-difficult scheme for iris localization: first pupil segmentation, then boundary localization and last eyelid detection. The scheme is selected because pupil edge is most distinct in our iris images and it is relatively easy to be localized. Local texture is important for iris localization and it is it is useful for saving computational time. Thus, pupil detection can provide useful information for boundary localization and eyelid detection.

1) Iris outer and inner boundary localization

Since, pupil is a black region with low frequency, they decompose the original image with Haar wavelet. Haar wavelet is selected because it has zero-phase and minor displacement when it is used to localize pupil. This quantizes the decomposition results. From this they can easily localize pupil in a coarse-to-fine strategy, i.e., computing the position of the iris. This strategy can filter much noise such as eyelash. When computing the parameters of the circles, thy use a modified Hough Transform to improve the speed. They select randomly three edge points in the edge map and computes the centroid and radius according to the equation:

$(x_i - a)^2 + (y_i - b)^2 = r^2$

From the experimental results it can be seen that the above method can reduce computational cost.

The outer boundary of an iris is localized with an integral differential operator. The differential operator is defined as

$f'(i) = f(i+1) + f(i+2) - f(i-1) - f(i-2)$

So it can improve the contrast of the outer boundary of an iris. If the pupil position is (x_c, y_c, r), the searching space of outer boundary is limited to

$(x_c - x_1, y_c, r + r_1) \sim (x_c + x_1, y_c, r + r_2)$

2) Upper eyelid localization

Author finds that the edge of the upper eyelid is generally contaminated by eyelashes; hence the upper eyelid localization is difficult because of the low SNR. So the traditional methods that combine edge detection with Hough transform are not very efficient and have some limits and an integral differential operator incurs high computational cost because it must search in a 3D parameter space. Considering the above two points, iris localization based on texture segmentation is adopted because they want to use not only gray information but also texture information. The method proposed in this paper uses the frequency property to segment eyelash. It avoids many false points because it adopts local texture property. The algorithm can be described as follows.

1) Segment eyelash region from the image to search the raw position of the eyelid. To segment the eyelash, they compute the energy of high spectrum at each region. If the high frequency is high enough, it can be seen as eyelash area.
2) Use the information of the pupil position to segment the upper eyelash.
3) Fit the eyelash with a parabolic arc
   $y = ax^2 + bx + c$.
4) Search in the neighbourhood field of the parabolic arc denoted by (a, b, c) to get the final result.

Where $curve(c) = ax^2 + bx + c - y = 0$ be a cluster of parabolic arc with variable parameter c.

3) Lower eyelid detection

Author segments the lower eyelid using the histogram of the original image. The threshold is defined by computing the mean and variance of the gray value of the pixels in the iris. They select the upper points of the lower eyelid under the pupil to search the edge of the lower eyelid according the following steps.

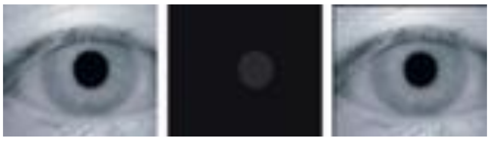
1) Segment the lower eyelid area;
2) Compute the edge points of the lower eyelid;
3) Fit the lower eyelid with the points obtained in step 2);
4) Search the final result in the neighbourhood field.

Step 3) and 4) are similar to step 4) and 5) in upper eyelid detection algorithm, respectively.

D. Proposed Technique of R P Ramkumar:-

1) Steps for Pupil localization

To detect the pupil boundary they use 3 phases, viz. scaling, reverse function, and four neighbours method respectively. The scaling phase (1 phase) deals with reducing the iris image size into the one-fourth of its original size, so that the region for thresholding process gets highly diminished, which in turn reduces the processing time and computational cost of system, so that it paves path for increasing the accuracy and efficiency of the entire iris recognition process. Since the pupil is darkest area in entire eye image, this portion is the distinguished by thresholding operation with the help of reverse function as shown in Fig. 2(a) and 2(b). This constitutes the second phase.



(a) (b) (c)

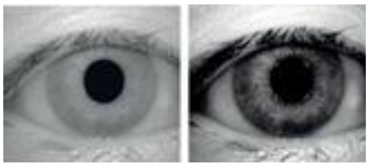
Fig 3. (a). Original image, (b) after applying negative function, and (c) Image after segmentation

As a result of this, pupil region is detected approximately and this constitutes the 1 phase of pupil localization stage. In the 3 phase, 4 neighbours method based on [9, 10] is applied for each pixel to the localize pupil boundary accurately.

Where (x-1, y) represents top most point, (x+1, y) represents bottom most point, (x, y-1) represents left most point and (x, y+1) represents right point most in pupil boundaries respectively. Now, the pixel values are checked such that, if its value is equal to the white and one of its 4 neighbours value is less than white colour, then the corresponding pixel value is replaced by the white colour else original eye image pixel value is the retained. Upon completing the above the 3 phases, pupil boundary is detected accurately as shown in Fig. 2(c), irrespective of its shape either the circle or the ellipse, with an average processing time of only 0.7 to 0.8 seconds.

2) Steps for Iris localization

Here 3 steps, viz. contrast enhancement, special wedges, and the thresholding are employed to detect specific iris regions from an eye image. The dedicated algorithm described in [11] is used for contrast enhancement, so that limbic boundary is identified clearly as shown in Fig. 3(b), when compared with the original image shown in Fig. 3(a).



(a) (b)

Fig 4. Eye image before and after enhancement process

Now, the pixels lying only within region of ±45˚ along with the central axis on both sides, i.e. left and right sides of iris regions, alone are considered as illustrated in [12] is shown in Fig. 4, which is free from eyelash and eyelid occlusions.

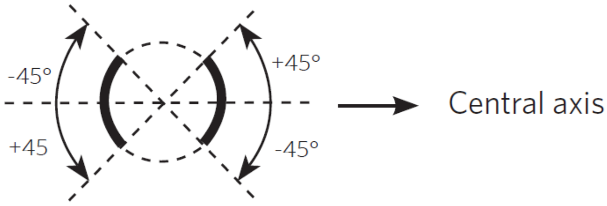


Fig 5. Measured regions of arcs in the iris region along the central axis

This portion of measured iris region is the maximum useful region with minimum noise and is said to be the Region of Interest (RoI), and its mean value is also calculated. By choosing the suitable and predetermined threshold value below the mean value, arc regions of iris alone are isolated and hence the process of iris segmentation from limbic boundary is accomplished perfectly.

E. Our Proposed Technique:-

The proposed method discusses the segmentation technique based on active contours. Active contours are dynamic curves that moves towards the object boundary.

They achieved this by explicitly defining an external energy that moved the zero level curves toward the object boundaries. It's been observed that the segmentation by active contours is 100% accurate compared to Daugman's inegro-differential method and the Hough transform with less computational time. This technique is given in detail as follows:-

1) *Active Contour Models*

Active contour models for localizing the pupil in eye images Ritter et al. [13]. Active contours respond to preset internal and external forces by deforming internally or moving across an image until the equilibrium is reached. The contour contains a number of vertices, whose positions are changed by the two opposing forces, an internal force, which is the dependent on desired characteristics, and an external force, which is the dependent on image. Each vertex is moved between the time t and t + 1 by

$$V_t(t+1)=v_t(t)+F_t(t)+G_t(t)$$

Where F_i is internal force, G_i is external force and v_i is position of the vertex *i*. For localizations of pupil region, the internal forces are calibrated so that the contour forms a globally expanding discrete circle. The external forces are usually found using the edge information. In order to improve accuracy, we use variance image, rather than the edge image.

A point interior to pupil is located from the variance images and then a discrete circular active contour (DCAC) is created with this point as its centre. The DCAC is then moved under the influence of the internal and the external forces until it reaches equilibrium, and thus pupil is localized.

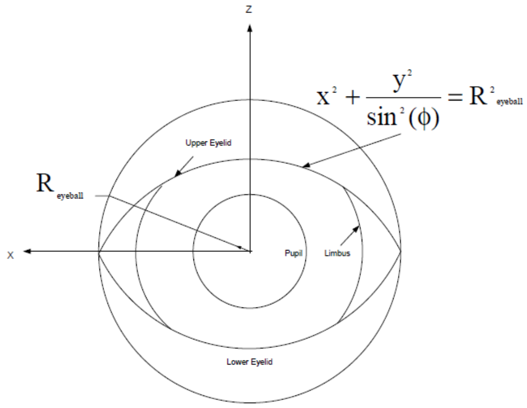


Fig 6. Eyelid curve model based on degree of eye openness: Front view.

2) Elliptic Eyelid Contour of Eyelid Model

An eyelid contour model is derived from assumption that an eyeball has a spherical shape. This assumption leads to an eyelid model based on openness of eye. The openness is defined as the angular position of an eyelid with the respect to the center of the sphere. Assuming that an eyeball can be presented as a sphere:

$$x^2 + y^2 + z^2 = R^2_{yeball}$$

An eyelid curve can be obtained by intersecting the sphere with a plane which passes through the x axis with an angle Φ with respect to the z axis. Figure 6 and 7 illustrate the side view and the front view of an eyelid contour considering the spherical shape of an eyeball and the expected eyelid curve in a specific degree of eye openness. This plane can be written as:

$$\tan(\phi) = \frac{y}{z}$$

The intersection curve simply becomes an elliptic curve:

$$x^2 + \frac{y^2}{\sin(\phi)^2} = R^2_{eyeball}$$

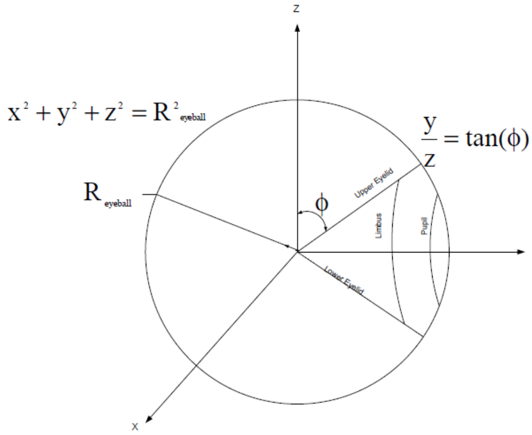


Fig 7. Eyelid curve model based on degree of eye openness: Side view.

This curve is then transformed to the polar coordinates to be more appropriate for our system:

$$x = r\sin(\mu);\ y = r\cos(\mu);$$

$$r = \frac{R_{eyeball}}{\sqrt{\sin(\theta)^2 + \frac{\cos(\theta)^2}{\sin(\phi)^2}}}$$

IV. DISCUSSIONS

The theoretical analyses of the high speed and robustness of the proposed method are as follows.

1) The efficient easy-to-difficult localization scheme is adopted. The localization method makes full use of the local information to reduce the effect of noise.
2) Pupil detection uses circle fitting, which is the solution of the parameter equations. The method is not the same as Hough transform and can reduce computational cost greatly.
3) In outer boundary localization, a high order differential operator is adopted to improve the iris image contrast. In addition, the search space reduces from 3D to 2D and we only search a small domain in the 2D space, therefore, the algorithm is fast and can avoid local maximum.
4) Upper eyelid detection is based on frequency characteristics of eyelashes and it is not affected by illumination. And the search space reduces from 3D to a small domain in 1D space, so the method is fast and robust.

In a word, the proposed method combines the edge and texture to localize the iris: (outer and inner) boundary and (Upper and lower) eyelid using active contours.

Table 1 Comparison of all algorithms

S. No	**Methods**	**Recognition Rate (%)**
1	Daugman[3]	98.60
2	Wildes[4]	99.50
3	Cui[5]	99.30
4	R P Ramkumar	100%
5	Our Proposed Algorithm	100%

V. CONCLUSION

This paper compares Daugman, Wildes, Cui and R P Ramkumar methods for Iris localization. But Iris localization serves not only computing the position of the iris, but also detecting the eyelids to get the visible part of iris. This paper compares all algorithms to localize iris based on texture segmentation. In Cui methods they localizes pupil with WT (wavelet transform) and iris boundary is localized with a differential integral operator. Edge of upper and lower eyelids is detected after eyelash and eyelid are segmented. And Daugman explains the iris recognition algorithms and presents results of 9.1 million comparisons among eye images from trials in Britain, the USA, Japan, and Korea. We use the spectral information to ovoid the false edge points that always exist in edge-detection based method. The compared results shows the R P Ramkumar's promising performance and robustness of the method by using Elliptic Eyelid Contour of Eyelid Model, and Active contour models. But it's been observed that the segmentation by active contours is 100% accurate compared to Daugman's integro-differential method and the Hough transform with less computational time which makes our algorithm faster and 100% efficient. So our algorithm is best in this compared paper, and in future we will do experiments to see up to how much extent the computational time is reduced by using active contours to improve the accuracy of iris recognition.

VI. FUTURE WORK

In this paper, Integro-differential operator is replaced by active counters to reduce the computational time of the algorithm. However, there is a possibility to explore the new method of finding iris region. Till now, various method of segmenting the iris region have been discussed such as; local entropy, SVDD classifier, integro-differential operator among these integer differential operator is most popular but the computation time is more while normalizing the iris. Processing time can be reduced by using Region of Interest method where only iris region can be extracted. Such type of techniques was proposed by Y. Caron et al. in 2007, used a power law models in detecting region of interest. Region of interest (ROI) is the part of the image for which the observer of the image shows interest in the particular region of the image. Further, results can also be validated with other distance measuring methods such as, Euclidean distance, city block cosine etc for matching two iris patterns instead of traditional Hamming Distance method.

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