ADAPTIVE IRIS LOCALIZATION AND RECOGNITION: MODIFICATION ON DAUGMAN'S ALGORITHM

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Abstract— the use of biometric information has been widely known for both people identification and security application. It is common knowledge that each person can be identified by the unique characteristics of one or more of biometric features. One most unique and identifiable biometric characteristics is the iris, wherever the second is the voice, and the third is finger print. This research attempts to apply iris recognition techniques based on the technology invented by Dr. John G. Daugman, an attempt of implementing a build an end user application. Iris Recognition is expected to play a major role in a wide range of applications in which a person's identity must be established or confirmed in high reliability and high privacy, Including access controls, authorizations, ID detection, etc. This research depends on standard iris images was token from CASIA database. The most efficient computer language for simulation and technical computing (MATLAB) will be used to make the problem statement and result in addition to mathematical and AI modelling more easier and reliable.

Keywords— Image Processing; Iris; Localization; Biometrics; Gradient

I. INTRODUCTION

Human Identification / Verification are an ancient goal of the humanity. Hence the technology and its services have developed in the modern world, human activities and transactions have increased in which rapid and reliable personal identification is required. Many examples include computer login control, passport control, bank automatic teller machines and other transactions authorization, access control, and security systems in general. All such identification efforts have the common goals of speed, reliability and automation [1].

Recorded voiceprints are susceptible to changes in many parameters affects the person's voice, systematic factors, non-systematic effects, and they can be counterfeited. Fingerprints or handprints require physical contact, and they also hard to implement and usage [7].

On the other hand, human iris print is an internal organ of the eye and had a special protection against the external environment. It is easily visible from within one meter long distance. This makes it perfect biometric information for an identification/verification system with the ease of speed, reliability and automation [2].

This research, experiment, implements, and also, looks into the theory of the Iris Recognition System. This related to the field of personal identification / verification and more specifically to the field of automated identification / verification of humans by biometric information.

II. IRIS BIOMETRICS

Any biometrics should have the specific attributes. The major one is the (DOF) degree-of-freedom of variance in the specified index related to the human population. This determines the uniqueness; its immutability over time and its immunity to intervention. The second attribute is the computational prospects for efficiently encoding and reliably recognizing. In the entire human population, no two irises are alike in their mathematical detail, even among identical (monozygotic) twins. The probability that two irises could produce exactly the same Iris Code is approximately 1 in 1078. (The population of the earth is around 1010) [14].

Possibility of using the iris of the eye as a kind of personal identification / verification optical like Fingerprint was first suggested by ophthalmologists who noted from clinical experience that every iris had a highly detailed and unique texture, which remained unchanged in clinical photographs spanning decades. The iris is composed of elastic connective tissue, the trabecular meshwork, whose prenatal morphogenesis is completed during the 8th month of gestation. It consists of pectinate ligaments adhering into a tangled mesh revealing striations, ciliary processes, crypts, rings, furrows, a corona, sometimes freckles, vasculature, and other features [2], [13], [14].

The color of the iris is usually changed by blanket of chromatophore cells during the first year of life, but trabecular pattern itself is stable throughout the lifespan according to the available clinical evidences. Properties that enhance its suitability for use in automatic identification include: its inherent isolation and protection from the external environment, being an internal organ of the eye, behind the cornea and the aqueous humor; the impossibility of surgically modifying it without unacceptable risk to vision and its physiological response to light, which provides a natural test against artifice [13][14].

The iris is shared with fingerprints in the property of random morphogenesis of its minutiae. The iris texture is stochastic or possibly chaotic. That is because of there is no genetic penetrance in the expression of this organ beyond its anatomical form, physiology, color and general appearance [13][14].

Because of the detailed morphogenesis of the iris depends the embryonic mesoderm’s initial conditions from which it develops the phenotypic expression even of two irises have the same genetic genotype, they must have uncorrelated minutiae. Thus, the uniqueness of specified fingerprint parallels the iris uniqueness, common genotype or not. But more advantages in particular can be extracted from this [12].

III. METHODOLOGY

After we acquire the image using camera the first stage of iris recognition is to isolate the actual iris region in a digital eye image. The iris region, shown in Figure 1.2, can be approximated by two circles, one for the iris/sclera boundary and another, interior to the first, for the iris/pupil boundary. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. Also, specular reflections can occur within the iris region corrupting the iris pattern. A technique is required to isolate and exclude these artefacts as well as locating the circular iris region [1].

The accuracy of iris segmentation depends on the imaging quality, and the pre-processing of the eye image. Images in the CASIA (the most famous, most used, and what we work on in this research) iris database do not contain specular reflections due to the use of near infra-red light for illumination. However, the images in the LEI database contain these specular reflections, which are caused by imaging under natural light. Also, persons with darkly pigmented irises will present very low contrast between the pupil and iris region if imaged under natural light, making segmentation more difficult. The segmentation stage is critical to

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the success of an iris recognition system, since data that is falsely represented as iris pattern data will corrupt the biometric templates generated, resulting in poor recognition rates [3].

A broad set of image processing operations that affects the image depending on shapes is so called MORPHOLOGY. Morphological operation applies a structure element to the image, the output resulted image will be the same size. Each pixel' value in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image [15].

The basic morphological operations is "Opening in" and "Closing". Morphological opening and closing changes the definition of pixel set depending on the neighborhood pixels and structure element. And the most basic operations in morphology are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as dilation or erosion. This table lists the rules for both dilation and erosion [15].

The structure elements used in this research is "Liner" and "Disk". Structure elements are the basic block of any morphological operation. Equation 1 represents "Linear" structure element, while the equation 2 represents a "Disk" structure element [15].

$$\begin{matrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix} \qquad (1)$$

$$\begin{matrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \end{matrix} \qquad (2)$$

Controlling the structural elements will generate a different images and different results of processing. The programmer matter is to determine and design the best structure element and the best parameter of that [15].

IV. RADON TRANSFORMAITON

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A standard mathematical model to represent the projection of geometric 2-D object into one dimension is implemented in computer vision algorithms in the name “Radon Transform”. That transform is usually used to determine the parameters of simple geometric objects by the means of projection, such as lines and circles, inside the image. Radon transform is often so called “Hough Transform” in image processing. It usually employed to detect the tangents and centre coordinates of the circular or curved regions. It’s very efficient in line detection [12].

In this research, an automatic segmentation algorithm based on Hough transform will build and tested. After building edge map in the eye image the Hough transform will be applied to specify parameters of circles passing through each edge point. These parameters are the centre coordinates xc and yc, and the radius r, which are able to define any circle [17].

The lines in the image is determined by the maximum point of projection in radon space in the Hough space and the corresponding radius and centre coordinates of the circle will be best defined by the edge points of the tangential line. Approximating the upper and lower eyelids with parabolic arcs will be available using radon transform based line detection [17].

According to the experimental results, the error in determining the iris coordinated and border should be substituted in a specific mathematical computational algorithm. The gradient is defines the variance between a set of mathematical data. Hence, the gradient can be implemented to get the maximum variance in between the iris and cornea [12].

The eyelid edge map will corrupt the circular iris boundary edge map if using all gradient data. Considering the vertical gradients only for locating the iris boundary will efficiently reduce influence of the eyelids after performing the radon transform. Horizontal gradient will be very useful in locating the iris boundary. Not only does this make circle localization more accurate, it also makes it more efficient, since there are less edge points to cast votes in the Hough space [17].

Two-dimensional gradient mathematical equation is described in equation 3 [12].

$$\lim_{h \to 0} \frac{\|f(x+h) - f(x) - \nabla f(x) \cdot h\|}{\|h\|} = 0 \tag{3}$$

V. SYSTEM DIAGRAM

This proposed systems works in two modes; the first is enrollment mode, and the second is identification mode. In the first mode, the templates will be taking and the iris code stored in the database. The second is the running mode in normal condition to get identification.

Figure 1 illustrates the program flow.

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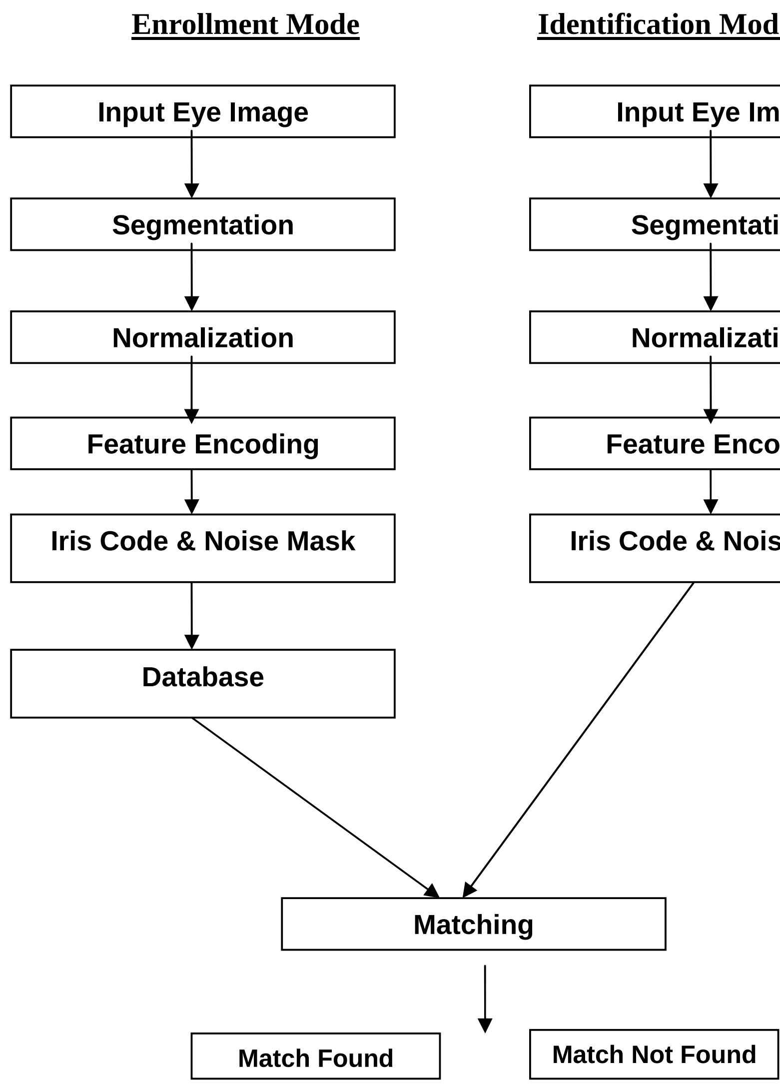

Fig. 1: Proposed System Flow Chart

VI. IRIS CODE

Feature encoding was implemented by convolving the normalized iris pattern with 1D Log-Gabor wavelets. The 2D normalized pattern is broken up into a number of -D signals, and then these 1D signals are convolved with 1D Gabor wavelets. The rows of the 2D normalized pattern are taken as the 1D signal; each row corresponds to a circular ring on the iris region. The angular direction is taken rather than the radial one, which corresponds to columns of the normalized pattern, since maximum independence occurs in the angular direction [3].

The iris intensity values at specific known noise areas in the normalized pattern are set to the mean intensity of neighborhood pixels to remove the influence of noise in the filter's output. The filtering output is then phase quantized to four levels using the Daugman method, with each filter producing two bits of data for each phase. The phase output quantization should be chosen to be a grey-level code, thus, when sliding between two quadrants, only one bit will change. This is minimizing the number of bits disagreeing, and thus will provide more accurate recognition. The feature encoding process is illustrated in Figure 2.The result code is so called "Iris Code" [3].

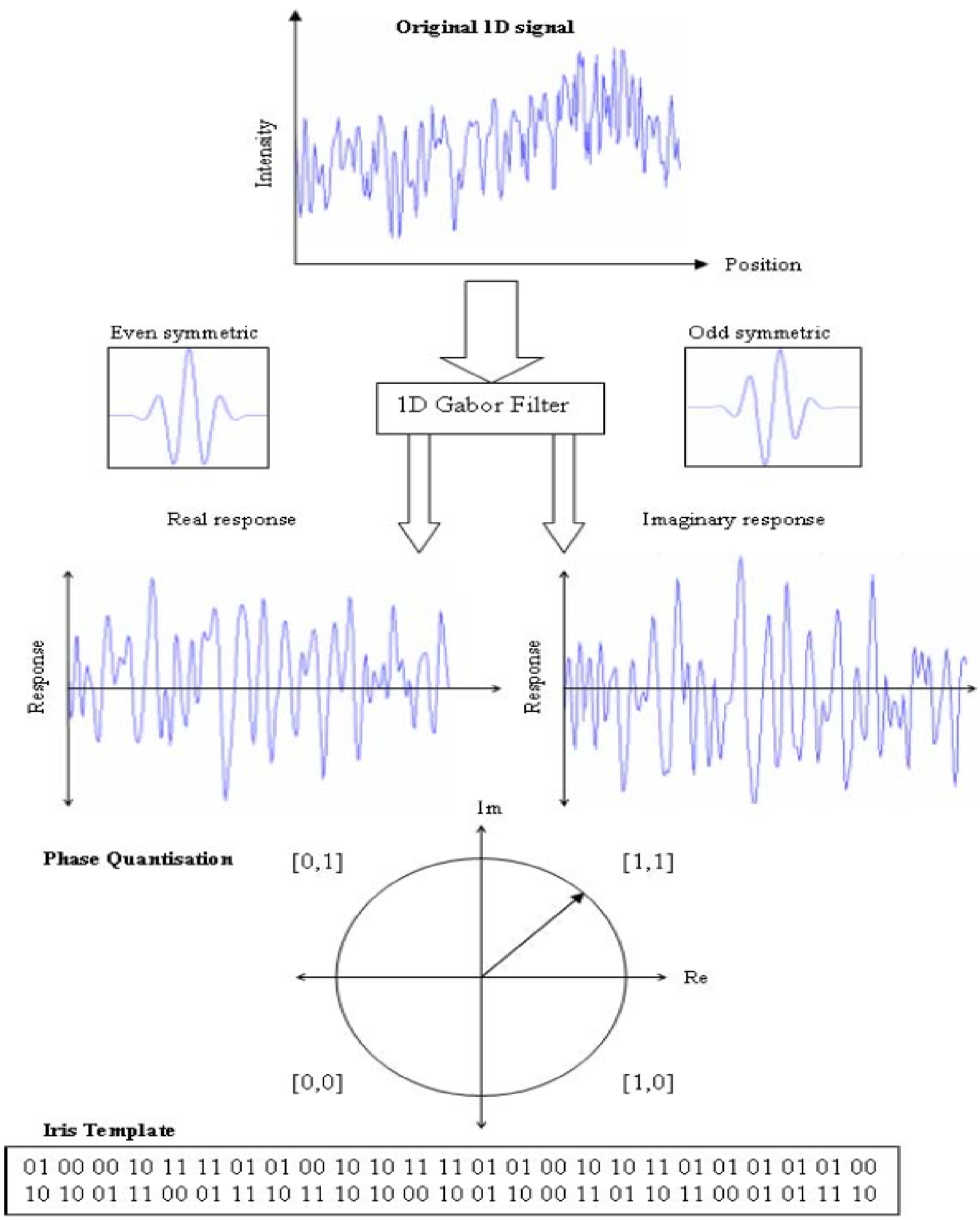

Fig. 2: Iris Code

A bitwise template is produced by the encoding process. This template is what so called "Iris Code" containing number bits carrying the information of the iris, and the noise mask which corresponds to corrupt areas within the iris pattern, and marks bits in the template as corrupt. The phase information is meaningless at the regions of zero amplitude, so, the noise mask will also mark these regions. The total number of bits in the iris template will be the radial

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resolution times the angular resolution, times 2, times the number of used filters. In this technique, the number of used filters and their centre frequencies, and the parameters of the modulating Gaussian function are responsible to achieve the best recognition rate. Figure 3 shows the iris code mask [1].

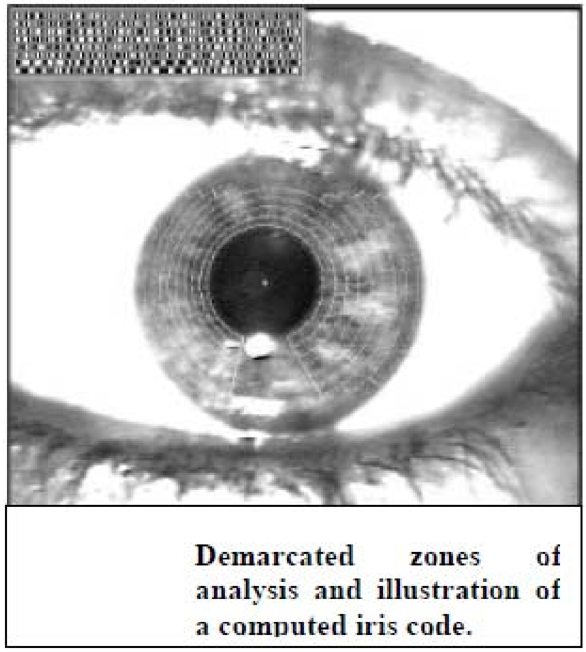

Fig. 3: More Illustration on Iris Code

VII. Matching

Daugman patented algorithm is concerns on matching the iris depending on Hamming distance represents the measure of how many bits are the same between two patterns of bits. The Hamming distance should be used between two bit patterns to generate a decision that can be whether the two patterns were generated from different irises or from the same one. For example the comparison between the two bit patterns X and Y, the equation Hamming distance, HD, is defined as the sum of disagreeing bits over N, the total number of bits in the bit pattern. HD is described in equation 4.

The HD for two codes generated from the same iris will be less than 0.3, and it larger than 0.3, the matching will get fail result (not match). Figure 4 shows examples of HD on different patterns [1].

$$HD = \frac{1}{N} \sum_{j=1}^{N} X_j (XOR) Y_j \qquad (4)$$

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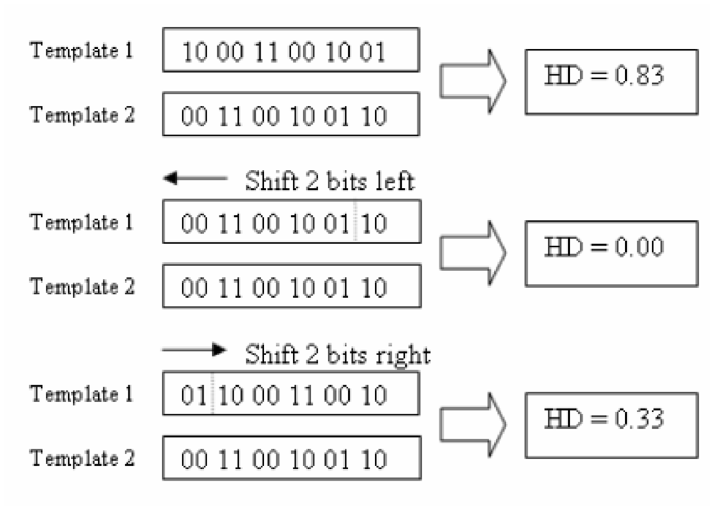

Fig. 4: Examples of Applying HD

VIII. RESULTS

The following figure illustrates the program flow from starting the iris image, passing through morphological preprocessing, Hough transformation, iris localization, and pattern isolation.

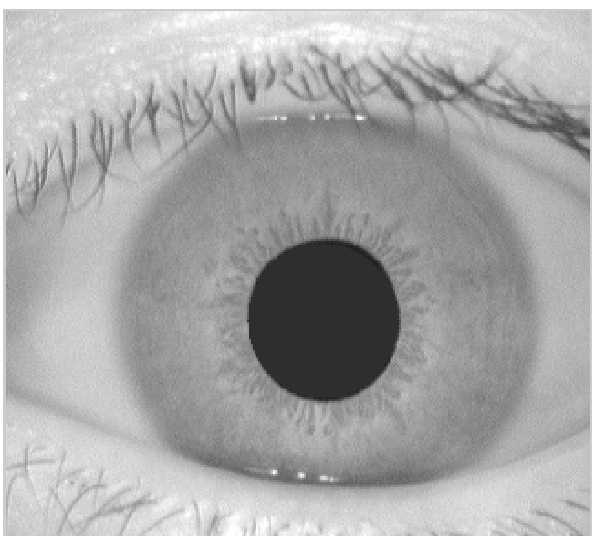

Fig. 5: Original Iris Image

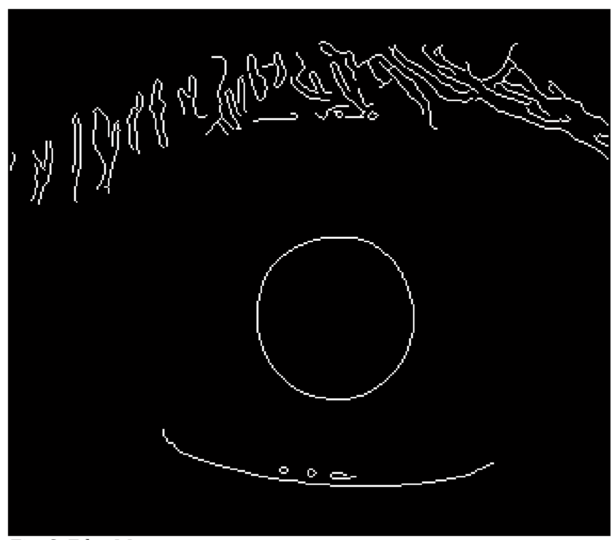

Fig. 6: Edge Map

The original image should be gray or converted to gray (see section 2.1). Sample iris is shown in figure 5, it relates to CASIA data base.

First preprocessing is the finding edge map using first derivative (Laplacian), edge map will enable to localize the pupil and determining the center of pupil. It could be used in gradient after some steps. Figure 6 shows the first edge map of the iris.

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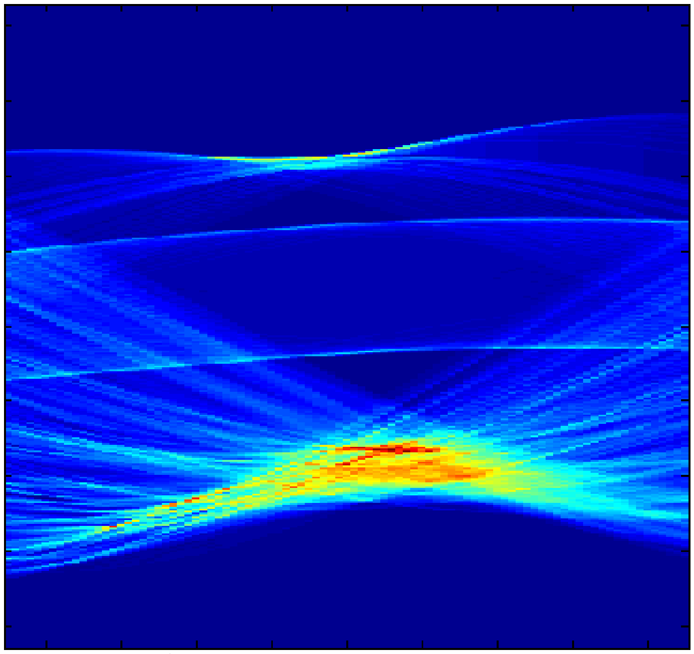

Fig. 7: Radon Transformation Diagram

The projection representation of the radon transform is shown in figure 7. It's clear from this representation that the pupil can't be isolated from this projection, because of the concentrated effect of eyelashes.

Reconstructing the image after transformation will result the image in figure 8, it's clear that the eyelashes is easier to localize after reconstruction. So, the combination of the Hough transform with morphology and computational mathematics would result best localizing of the iris.

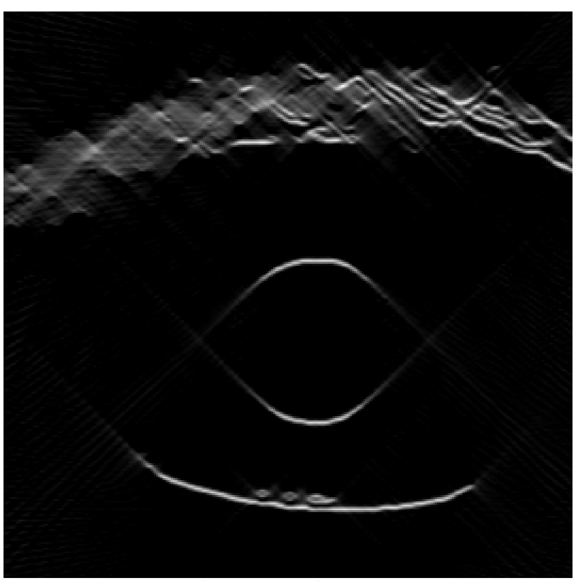

Fig. 8: Reconstruction of Radon Transformed Image

Fig. 9: Dilated Image

Figure 9 shows the dilation morphology of the image. This improves in connecting the objects which has some cutting or some erosion.

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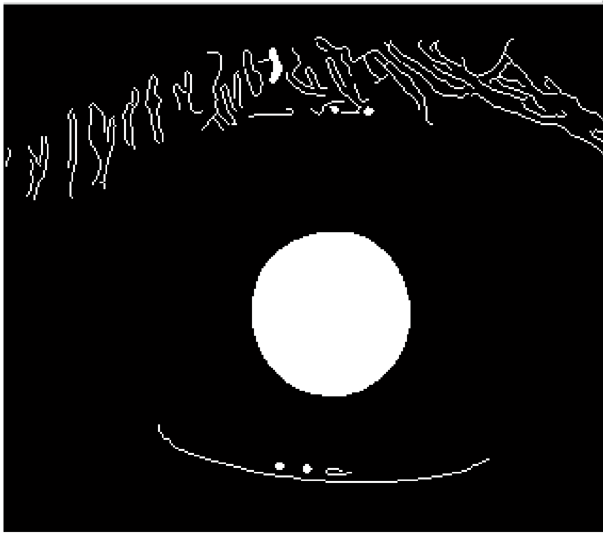

Fig. 10: Localizing the Pupil as Solid Object

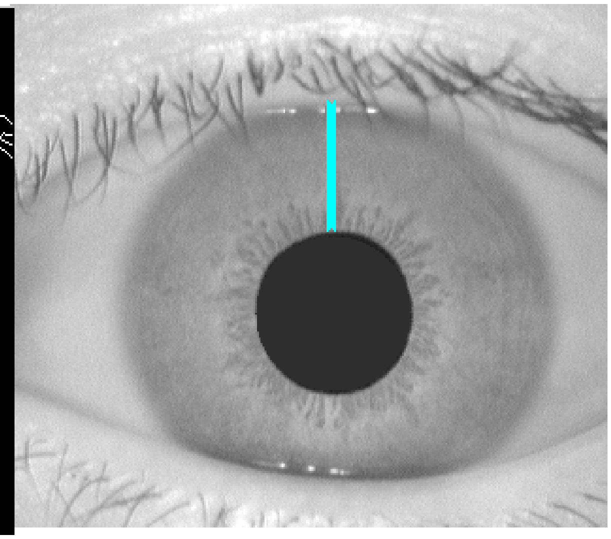

Fig. 11: Vertical Gradient

Now, to determine the centroid of the pupil, filling of the closed objects in edge map will close the pupil. After that, the region properties of it would be easy to calculate. The other processes will use the centroid of the pupil. Figure 11 shows the vertical gradient path in mathematical calculation.

Attempting to localize the iris is done using Hough transformation and gradient to substitute its error. First, using the Hough transformation to determine the eyelashes, the error in this way should be substituted. Figure 12 illustrated the iris localization using Hough transform in red color.

The blue circle in figure 12 illustrates the starting of gradient calculations. This circle limit was been found using the morphology. The final step is calculating the gradient between the pupil limit and the end of the eye. The contribution in such way is minimizing the error or Hough transform. The green circle in Figure 12 ensures the good performance of proposed gradient method.

The next step after localizing the iris is isolating it. Mathematical circle equation is used in geometry to make every pixel out of the iris circle returns zero, as Figure 13.

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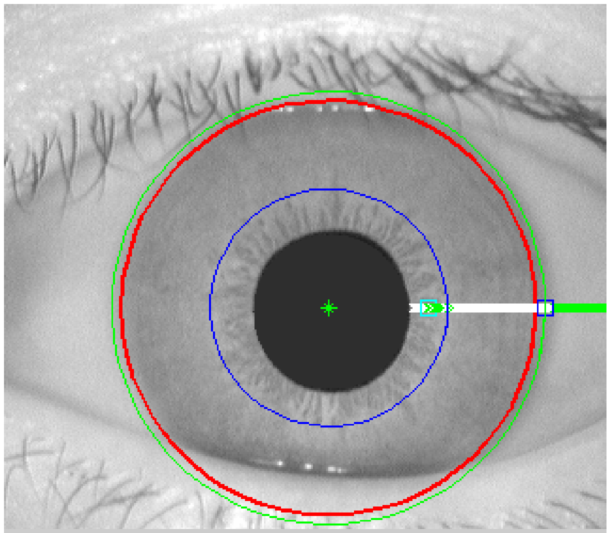

Fig. 12: Localizing the Iris

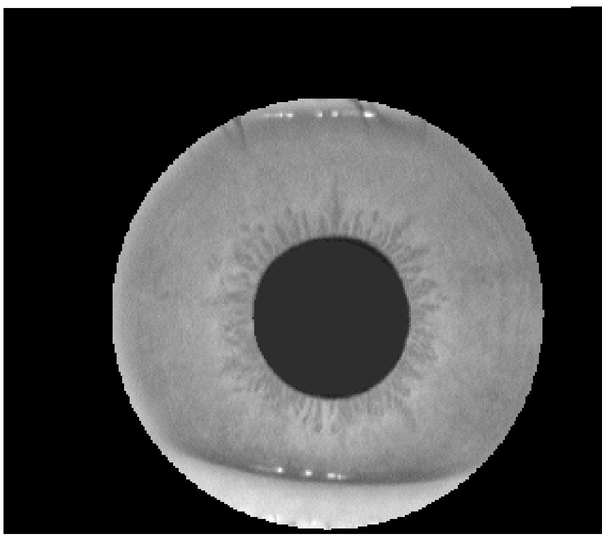

Fig. 13: Detecting the Iris

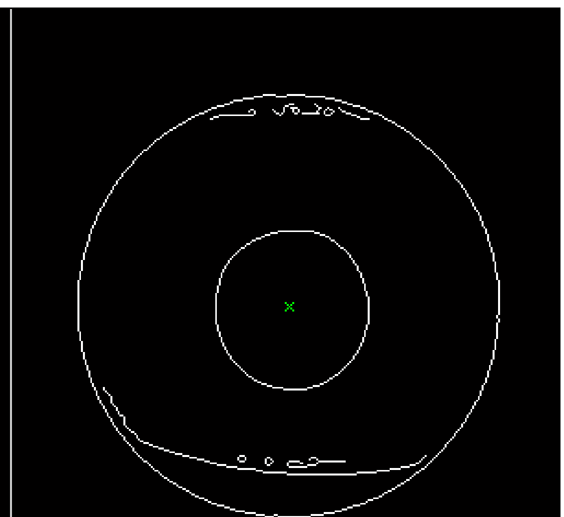

Fig. 14: Edge of the Detected Iris Circle

After the past isolation of the iris, a part of eyelids and eyelashes is still in the area of interest. Another morphological operation takes place and the limit of eyelids and eyelashes is easier to detect here. Figure 14 shows the new edge map.

The final step concerns total isolation of the iris and determining the pupil parameters (centroid and bounding circle). Efficient localizing of iris is proposed in this part, and the image is ready to get in recognition phase. Figure 15 shows the final isolated iris.

Daugman was suggested his frame work as cropping a 2048 pixel part from any location of the iris. This part will be the main array to perform iris code generation and then matching phase. A sample of cropped rectangle shown in Figure 16

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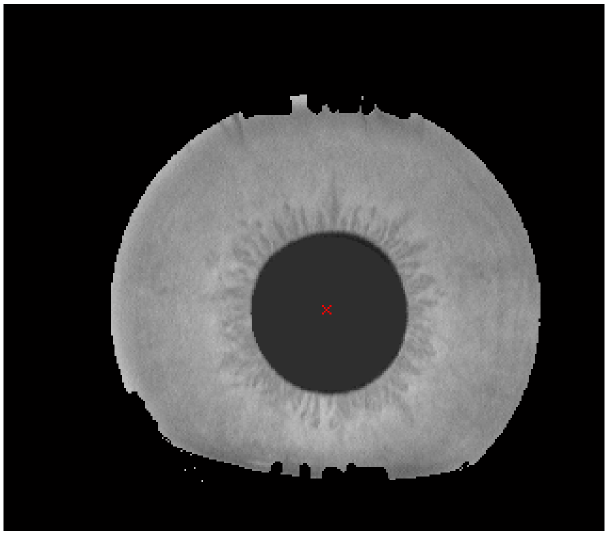
Fig. 15: Final Segmented Iris

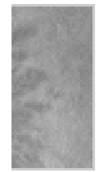
Figure 16: Iris Part to be Recognized

IX. Conclusion

Iris has the major parameters and features make it important in human identification / verification. All iris recognition applications currently available and all current pass researches depends on patented Daugman's algorithm. This research implements a program to apply the Daugman's equations, and thus perform the iris identification for sample of irises gotten from CASIA data base.

An algorithm for automatic segmentation illustrated and implemented, which localize the iris region in the eye image and isolate from every things around it (i.e. eyelid, eyelash and reflection areas).

Feature extraction of the iris and application of the iris code in the Human Distance (HD) equation, is very reliable for iris recognition for both applications; identification and verification. The HD is the matching metric, which gave a measure of how is two templates related to each other. The statistical dependence test failure of two irises would result a Not-Match.

Finally, the program has been tested in sample irises and gives a full performance in identification.

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