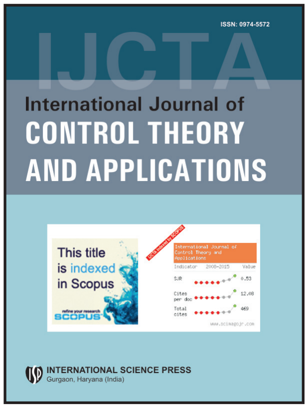

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Personal Authentication System by Iris Biometric Using Log Gabor Filter Technique

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Abstract: Face and iris localization is one of the most dynamic research areas in image understanding for new applications in security and theft prevention, as well as in the development of human–machine interfaces. This paper presents the details related to personal authentication system by iris biometric using log gabor filter technique. Various Iris technological modules and models have been outlined. Various steps related to Iris code generation and implementation have been explained in detail. CASIA database has been used for verification of methodologies and simulated results. From the studies, it is found that the results obtained from Circular Hough Transform are more accurate than those obtained from morphological operations.

Keywords: Personal authentication; Iris biometric; CASIA database, Gabor filter technique.

1. INTRODUCTION

Biometric techniques are usefull in identifying individuals by performing various functions uniquely identifiable physical or behavioral characteristics They are one of many such kind of techniques [1,2]. Biometric features that are usefull for in real world are the voice, face, retina, fingerprints, deoxyribonucleic acid (DNA), and the iris, they are usefull in identifying individuals uniquely as they differ from one human being to another.

Iris recognition is considered as one of the most authentic methods of biometric recognitionon, its use for identification and verification is crucial because it is considered as a reliable solution in establishing or determining a person's identity[5]. It is mentioned in the literature that the it is almost impossible to find two persons with similar iris features or it can also be said that the probability in finding such a pair is almost zero [3].

Access control to users for Networked access to computer applications is one area where iris recognition technology is an important solution and is evolving as a more reliable and also being popular for people identification in various other fields[5]. The the physical structure of the iris comprises unique features, such as stripes, freckles, coronas, etc. Ma et. al., 2003 [4] play a key role in identifying individuals uniquely. Some investigations in this field were already reported in the literature [6-8].

Features extraction is the most important step in the process of extracting information from the iris. All these features can be extracted using various algorithms image[11]. Iris features are extracted using various algorithms and is the pivotal step of the whole iris recognition process for individual identification. Here, a set of mathematical parameters or mathematical equations are derived from the two dimensional image, so that algorithms that are designed will have easy way of removing unnecessary data and focusing on the unique features that are represented in the form of mathematical equations.

The encoding of the significant features of the iris will be made and store which are usefull in comparisons that are done between templates are valid. The image of a human iris (i) Constitutes a plausible biometric signature for establishing or confirming personal identity (ii) that makes it superior to finger prints for automatic identification systems include, among others, the difficulty of surgically improving its texture without risk, its deep-rooted protection and isolation from the physical environment (iii) Is easily monitored physiological response to light. (iv) Iris will have permanent polar geometry that is implied because of it's structure make the process of feature extraction easier and also enables the ease of registering the iris optically without physical contact that feature is not the case for the finger print recognition. This paper presents the details related to personal authentication using IRIS images by employing log gabor filter technique.

Related Work

Performance of Log-Gabor Filters is better than other filtering techniques such as Gaussian, Mean, Median, and Wavelet filters in the following way: (1) The Gabor (Gaussian) filter shape offers an optimal joint localization in frequency and space. (2) Odd and even parts which permit a better imprison of both edges and ridges makes the Log-Gabor functions to be complex valued instead of real or integer valued. (3) The oriented high-pass log-Gabor filters are smooth and without extra side-lobes in space. (4) The proposed log-Gabor filters have elongated shape whereas other filters are more isotropic in size, i.e. log-Gabors have larger bandwidth in frequency and narrower bandwidth in orientation (37 degrees against 50 degrees for steerable) (5) The log-Gabor functions should match better with edges of natural images (yielding a stronger statistical differential response between edge and noise features) and as an additional advantage they can appear more ”usual looking” to human observers.

Gabor filter in Matlab: g = gabor(wavelength, orientation) Creates a Gabor filter with the precise wavelength (in pixels/cycle) and orientation (in degrees) Apply Gabor filter or set of filters to 2-D image: [mag, phase] = imgaborfilt(A, wavelength, orientation) Computes the magnitude and phase response of a Gabor filter for the input grayscale image A. wavelength describes the wavelength in pixels/cycle of the sinusoidal carrier. Orientation is the orientation of the filter in degrees.

The Circular Hough Transform (CHT) is a basic technique used in Digital Image Processing, for detecting circular objects in a digital image. The purpose of the technique is to find circles in imperfect image inputs. In a two-dimensional space, a circle can be described by:

$$(x - a)^2 + (y - b)^2 = r^2$$

Where (a, b) is the center of the circle, and r is the radius.

If a 2D point (x, y) is fixed, then the parameters can be originate according to (1). The parameter space would be three dimensional, (a, b, r). And all the parameters that satisfy (x, y) would lie on the surface of an overturned right-angled cone whose apex is at $(x, y, 0)$. In the 3D space, the circle <https://en.wikipedia.org/wiki/Circle_Hough_Transform> parameters can be identified by the intersection of many conic surfaces that are defined by points on the 2D circle. This process can be divided into two stages.

The first stage is fixing radius then find the optimal center of circles in a 2D parameter space. The second stage is to find the optimal radius in a one dimensional parameter space.

The comparison of various biometric techniques are as follows [21].

Table 1
Comparison of various biometric technologies (H = High, M = Medium, L = Low)

Biometrics	*Universality*	*Uniqueness*	*Permanence*	*Collectability*	*Performance*	*Acceptable*	*Circumvention*
Face	H	L	H	H	L	H	L
Fingerprint	H	H	H	M	H	M	H
Hand Geometry	M	M	M	H	M	M	M
Keystroke	L	L	L	M	L	M	M
Hand Vein	M	M	M	M	M	M	H
Iris	H	H	H	M	H	L	H
Retinal Scan	H	H	M	L	H	L	H
Signature	L	L	L	H	L	H	L
Voice	M	L	L	M	L	H	L
DNA	H	H	H	L	H	L	L
Gait	M	L	L	H	L	H	M
Ear	M	M	H	M	M	H	M

2. IRIS TECHNOLOGICAL MODULES AND MODELS

Iris technological modules:

- Normalization
- Segmentation
- Feature Encoding
- Matching Algorithms

Normalization being the other technological module. The important step after segmentation from eye images to transform iris region so that it has fixed dimensions in order to allow comparisions. The stretching or elongation caused by pupil dilation from varying levels of illumination causes the dimensional inconsistencies between eye images.

The important sub modules of segmentation main module are listed below:

- Daugman's Integro-differential Operator
- Hough Transform
- Gaussian pyramid and canny edge detection method
- Active Contour Models
- Circular symmetric filters
- Eyelash and Noise Detection

Figure 1 presents the typical sub modules of normalization. Feature encoding is one of the main modules of iris recognition system.

The most discriminating information present in an iris pattern must be extracted so that an accurate recognition of the individuals can be made by the end of the process.

Figure 2 represents the technological sub modules of Feature Encoding.

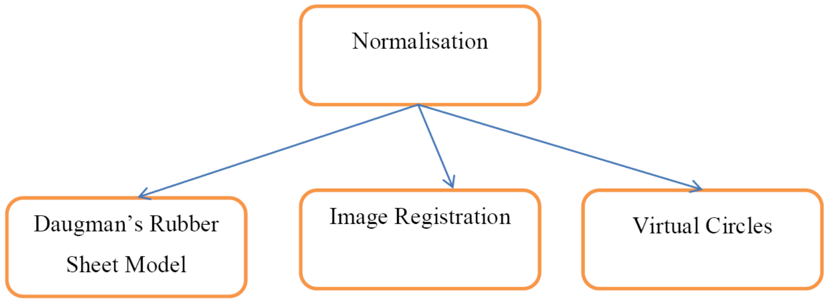

Figure 1: Technological sub modules of Normalization Module

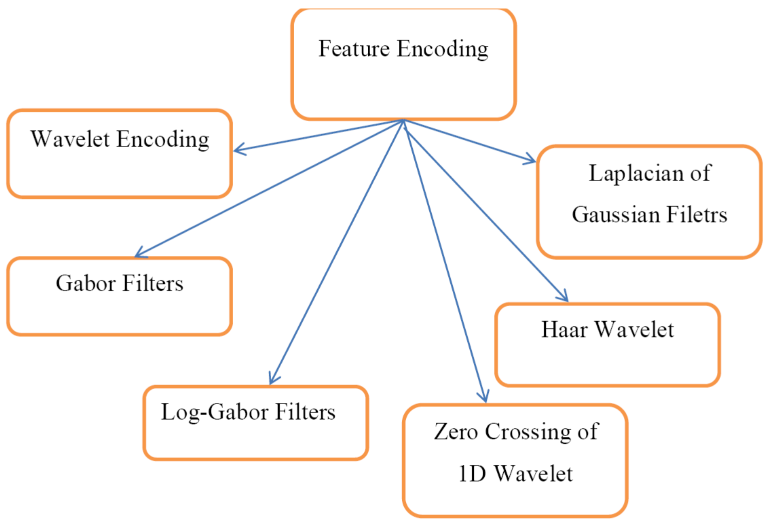

Figure 2: Technological Perspective in Feature Encoding

3. PERSONAL AUTHENTICATION UTILIZING IRIS IMAGES USING LOG GABOR FILTER TECHNIQUE

The processing of the personal authentication method according to the present embodiment is described below flowchart of Figures 3 and 4. Steps S**11** through S**17** constitute an iris code generation method is shown in flowchart.

The first aspect of the present invention provides an iris code generation method including the steps of:

(a) A step of capturing a plurality of iris images that include a same eye;

(b) A step of transforming a coordinate system of each of the iris images from a rectangular coordinate system to a polar coordinate system;

(c) A step of performing rotational compensation on each of the coordinate transformed iris images;

(d) A step of adding together each of the rotationally compensated iris images, while attaching a weight to each pixel value in each coordinate of the polar coordinate system, to accumulate them as a single iris image.

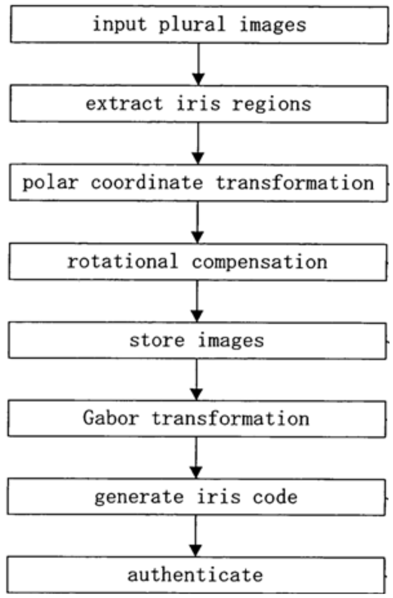

Figure 3: Methodology for Personal Recognition System

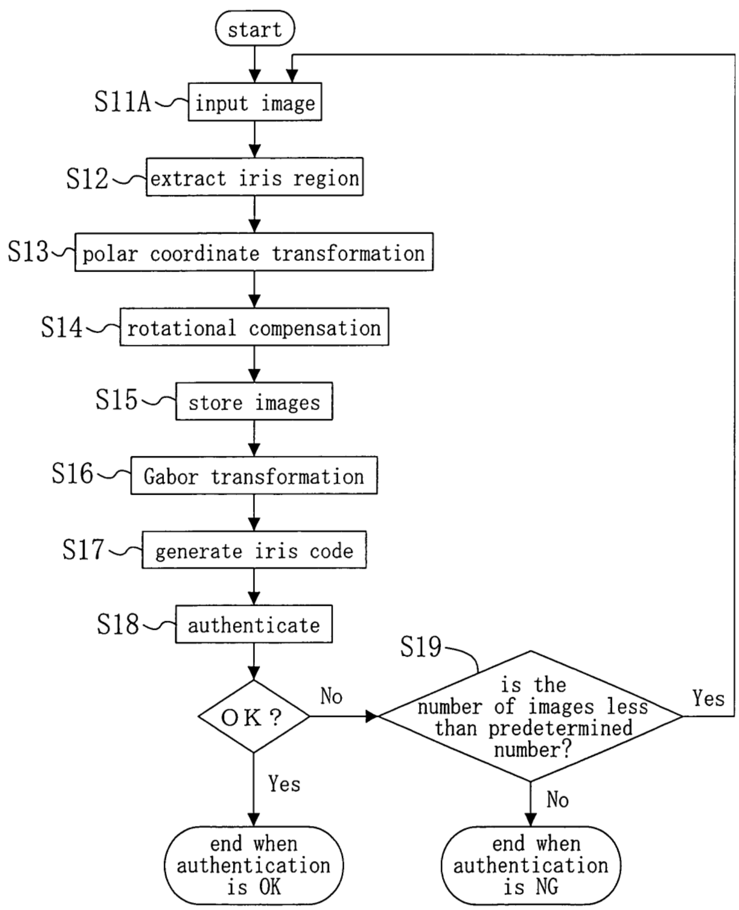

Figure 4: A modified iris authentication method

A step of generating an iris code from the single iris image, wherein in the weighted addition in the accumulation step, the weight is set smaller as a distance between a coordinate value in the original rectangular coordinate system corresponding to a coordinate of the polar coordinate system and a coordinate value of a pixel in the vicinity thereof is larger.

4. IRIS CODE GENERATION AND USER

An iris code is generated through the following steps:

- Obtain an iris image
- Detect the pupil perimeter (pupil/iris border) and the iris perimeter (iris/sclera (white portion) border) from the obtained image to extract an iris region
- Transform the image of the iris region to a polar coordinate transformed images
- Apply multi-scale 2-d Gabor transformation to the polar coordinate transformed image and
- Binarize the real part and imaginary part of the Gabor transformed data to generate an iris code

Then, at the time of registration, an iris code for a registrant is generated through the above steps and is registered in a registration database. On the other hand, at the time of authentication, an iris code for a person who is to be authenticated is generated through the above steps and is compared with the iris code in the registration database to determine, based on a difference between the iris codes, whether or not he/she is a person who has been registered in the registration database.

A. Obtain Iris Image

The iris image is captured using a camera similar to that in a home video camcorder shown in Figure 5. The iris is illuminated with low level IR illumination similar to that used in a wireless television remote control. The Institute of Automation from the Chinese Academy of Sciences (CASIA) developed the CASIA image database [13]. Apart from being the oldest, this database is clearly the most known and widely used by the majority of the researchers. CASIA iris image database (version 1.0, the only one that we had access to) includes 756 iris images from 108 eyes, hence 108 classes. For each eye, 7 images were captured in two sessions, where three samples were collected in the first and four in the second session. Its images were captured within a highly constrained capturing environment, which conditioned the characteristics of the resultant images. They present very close and homogeneous characteristics and their noise factors are exclusively related with iris obstructions by eyelids and eyelashes.

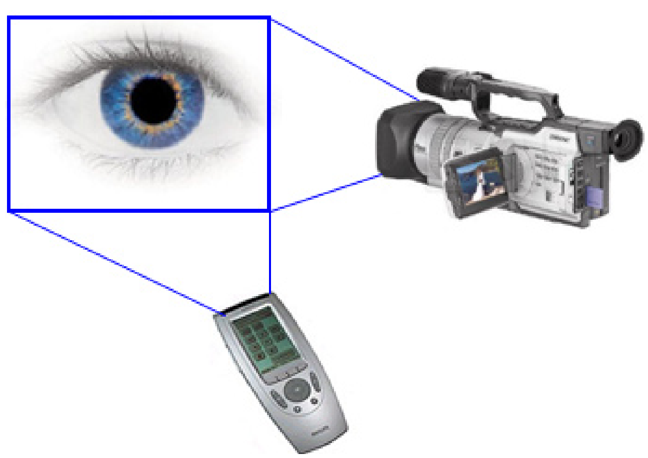

Figure 5: Image capture

Moreover, the post-process of the images filled the pupil regions with black pixels, which some authors used to facilitate the segmentation task. From this viewpoint, this significantly decreased the utility of the database in the evaluation of robust iris recognition methods [13]. Figure 6 shows a set of four randomly selected images of CASIA database.

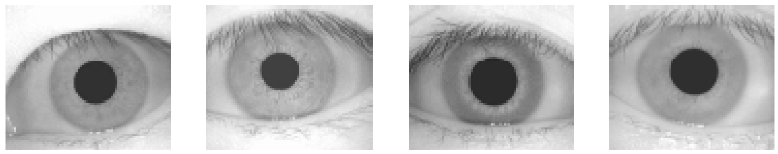

Figure 6: Examples of Iris Images from the CASIA Database

B. Detect the Pupil Perimeter And The Iris Perimeter

In general, any eye image contains not only the region of interest; the human iris, but also some unuseful parts (e.g. eyelid, eyelashes, pupil reflection, as well as different types of artifacts). In addition, a change in the camera-to-eye distance as well as the camera resolution may result in a possible variation in the size of the same iris taken at different scenes or by different cameras [11]. Furthermore, the brightness is not uniformly distributed because of non-uniform illumination.

Using Median Filter to Remove Noise

A median filter is a kernel based, convolution filter which blurs an image by setting a pixel value to the median of itself with its neighbors. A naive approach to applying a median filter would be to simply find the median for a given area around each pixel by sorting an array and finding the median to replace the current pixel with.

The overall effect of the median blur is to reduce the noise and pixel intensity complexity of the iris image without perturbing the edge fidelity of the original image. This results in a stronger clustering of pixel values in the resultant pixel data histogram; this permits a largely noise-free, dynamic analysis of features which occupy discrete pixel ranges, such as the pupil (see Figure 7).

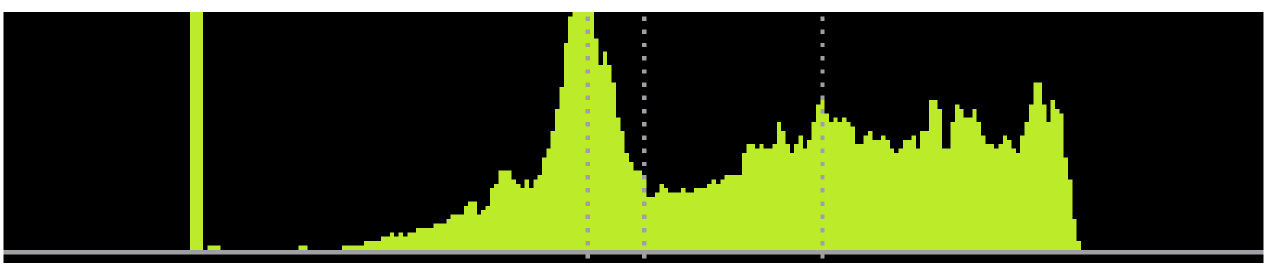

Figure 7: Generated Histogram

Upon application of a dynamic threshold to our median blurred image the leftmost image in Figure 6 is obtained. The location of the pupil is well defined, and edge detection can extract this information to form a single bit depth image which can be searched for circles. The pupil's intensity and location are fairly consistent in most images and so it lends itself well to auto-detection. Detection of the pupil can be carried out by: removing noise by applying a median blur, thresholding the image to obtain the pupil, performing edge detection to obtain the pupil boundary and then identifying circles. Properly detecting the inner and outer boundaries of iris texture is significantly important in all iris recognition systems. Pupil and limbus are often modeled as circles and the two eyelids are modeled as parabolic arcs [20]. However, according to our observation, circles cannot model pupil boundary accurately. Irregular boundary of pupil is the motivation to create an accurate pupil detection algorithm so two techniques were utilized: (i) morphological and (ii) Circular Hough Transform (CHT). The performance of these two techniques was evaluated with and without eyelashes[13].

Morphological-Based Method

In an iris image, the pupil typically appears as a large dark mass, the largest homogeneous region of dark pixels in the image [14]. Morphological algorithm takes advantage of this fact by isolating the darker regions of the image to create binary image, and then performing binary morphology in order to determine which region is actually the pupil. We remark that no assumptions are made to where the pupil lies within the image. Also, since all images we consider are orthogonal (meaning the eye peers straight into the camera, we assume for convenience that pupils are pure circles (and later, irises also), then we compute the pupil center and radius. The pupil center can be used to detect the approximate inner and outer iris boundaries. After that the detected pupil is superimposed over the original image to ensure that the pupil was correctly detected (see Figure 8).

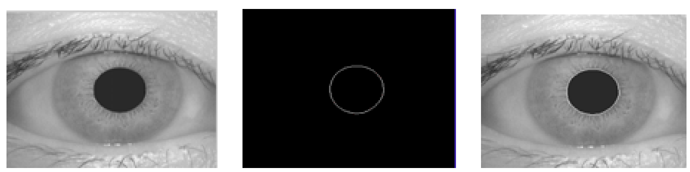

Figure 8: (a) Original image; (b) inner iris edge and (c) localized pupil

Before extracting features from the original image, the image needs to be preprocessed for accurate iris localization and normalization; which reduces the influence of reflections and artifacts. For this work, the Institute of Automation from the Chinese Academy of Sciences (CASIA) database has been used in which no reflections and no pupil artifacts exist. Only one needs to remove eyelashes if needed using an adaptive black mask of size determined according to the detected iris size[16]. The gabor filter is an edge detection technique which calculates the gradients (in both the x and y direction) of the image intensity for each pixel and then combines them to give a gradient magnitude. This indicates how sharp the boundary is, which is itself an indication an edge is present.

As can be seen in Figure 9 the result of this process of filtering is a circular artifact denoting the extremities of the pupil in the image. This data requires further analysis for the presence of circular artifacts to acquire a "best-fit" representation of the potentially elliptical pupil.

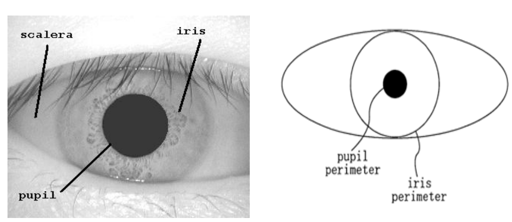

Figure 9: Pupil perimeter and iris perimeter

Hough Transform for Edge Detection

Hough transform is a standard image analysis tool for finding curves that can be defined in a parametric and not parametrical form such as lines, polynomials, and circles. The recognition of a global pattern is achieved using the local patterns. For instance, recognition of a circle can be achieved by considering the strong edges in an image as the local patterns and searching for the maximum value of a circular Hough transform. Wildes et. al., (1996) [15] used Hough transform to localize irises. The localization method, similar to Daugman's method, is also based on the first derivative of the image. In the proposed method by Wildes, an edge map of the image is first obtained by thresholding the magnitude of the image intensity gradient [17].

$$|\Delta G(x, y) \times I(x, y) \quad (1)$$

where,

$$\delta = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}\right) \text{ and}$$

$$G(x, y) = \exp\left(\left(-(x - x_0)^2\right) + (y - y_0)^2\right)/2\sigma^2)/2\pi 6^2$$

$G(x, y)$ is a Gaussian smoothing function with scaling parameter σ to select the proper scale of edge analysis. The edge map is then used in a voting process to maximize the defined Hough transform for the desired contour. Considering the obtained edge points as $(x_j, y_j) = 1, 2, ..., n$, Hough transform can be written as:

$$H(x_c, y_c, r) = \sum_{j=1}^{h} h(x_j, y_j, x_c, y_c, r) \quad (2)$$

Where,

$$h(x_j, y_j, x_c, y_c, r) = \begin{cases} \geq 1 \text{ if } g(x_j, y_j, x_c, y_c, r) \\ 0 \text{ otherwise} \end{cases}$$

The limbus and pupil are both modeled as circles and the parametric function g is defined as:

$$g(x_j, y_j, x_c, y_c, r) = (x_j - x_c)^2 + (y_j - y_c)^2 - r^2 \quad (3)$$

Assuming a circle with the center (x_c, y_c) and radius r; the edge points that are located over the circle result in a “zero” value of the function. The value of g is then transformed to “one” by the h function, which represents the local pattern of the contour. The local patterns are then used in a voting procedure using the Hough transform, H, in order to locate the proper pupil and limbus boundaries. In order to detect limbus, only vertical edge information is used. The upper and lower parts, which have the horizontal edge information, are usually covered by the two eyelids. The horizontal edge information is used for detecting the upper and lower eyelids, which are modeled as parabolic arcs [17]. Figure 10 illustrates the segmented human iris with and without eyelashes using the circular Hough transform.

Figure 10: Threshold image before and after edge detection with a 2D Sober convolution filter

The Hough Transform is implemented to locate the pupil (and subsequently the iris). Given a regular curve - in this case a circle - and a suitable range of parameters - x centre, y centre and radius - the generalized Hough transform can query individual pixels in an image for their contribution to a globally consistent solution for any parameters within the valid range. Due to the high computational complexity of the Hough transform technique (the parameter space for a simple circle is in three dimensions and depending on valid ranges this can quickly grow to millions of computations) and previous considerations for application performance, a number of elements were streamlined to accelerate the computation.

Thresholding the input image has the inherent benefit of changing the virtual bit depth of the image to 1 (black or white). Furthermore, the implemented algorithm saves time by only operating on black pixels - a greyscale implementation would significantly add to the processing time. Additionally a search on the threshold result (Figure 12) gives confident parameter estimations for centre and radius which can be used to constrain and guide the Hough algorithm.

As can be seen in Figure 11, this process gives fast, accurate and reliable solutions for circular artifacts in the thresholded and edge detected pupil image. The basis of iris auto-detection relies on this process.

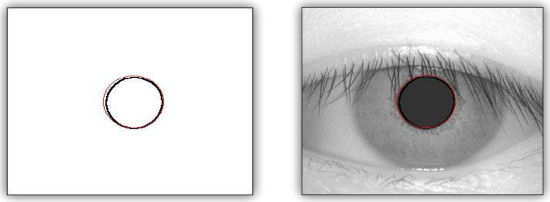

Figure 11: Hough transforms solution for a circle (red), given edge detected pupil

C. Transform the Image of the Iris Region to a Polar Coordinate

Once we have the location of the pupil clearly defined, the complexity of locating the iris is somewhat reduced due to the relative concentricity of the pupil and iris.

In contrast to pupil detection, efficiently locating the iris is somewhat more complicated due to (i) the obstruction of the iris by the eyelids for most eyes, (ii) its irregular pattern and (iii) because of the relative similarity with the iris boundary and the sclera. Nevertheless, following a similar method to that of locating the pupil generally provides good results. Again, a median filter is applied to the original image in order to remove noise from the image and to strengthen the clustering in the pixel histogram.

Normalization refers to preparing a segmented iris image for the feature extraction process. In Cartesian coordinates, iris images are highly affected by their distance and angular position impact on pupil size and causes non-linear variations of the iris patterns. A proper normalization technique is expected to transform the iris image to compensate these variations. There are many methods for normalization; in this work Daugman's method was used [15]. Daugman's normalization method transforms a localized iris texture from Cartesian to polar coordinates. The proposed method is capable of compensating the unwanted variations due to distance of eye from camera (scale) and its position with respect to the camera (translation). The Cartesian to polar transform is defined as shown in Figure 12.

$$x(\rho, \theta) = (1 - \rho) \times x_p(\theta) + \rho \times x_1(\theta) \tag{4}$$

$$y(\rho, \theta) = (1 - \rho) \times y_p(\theta) + \rho \times y_1(\theta) \tag{5}$$

where,

$$x_p(\theta) = x_{\rho o}(\theta) + r_p \times \cos\theta \;\; y_p(\theta) = y_{\rho o}(\theta) + r_\rho \times \sin\theta$$

$$x_j(\theta) = x_{jo}(\theta) + r_j \times \cos\theta \;\; y_j(\theta) = y_{jo}(\theta) + r_j \times \sin\theta$$

The process is inherently dimensionless in the angular direction. In the radial direction, the texture is assumed to change linearly, which is known as the rubber sheet model. The rubber sheet model linearly maps the iris texture in the radial direction from pupil border to limbus border into the interval (0 1) and creates a dimensionless transformation in the radial direction as well [4]. The resultant histogram is used to identify a point that can be used to threshold the image to produce an image similar to Figure 13. The method involves finding the peaks of the histogram (excluding the left-most peak that represents the pupil) and choosing a threshold value between these points. Although not always optimum, this method generally creates an image that the Hough Transform can use to find an approximate match for the iris; other, potentially better.

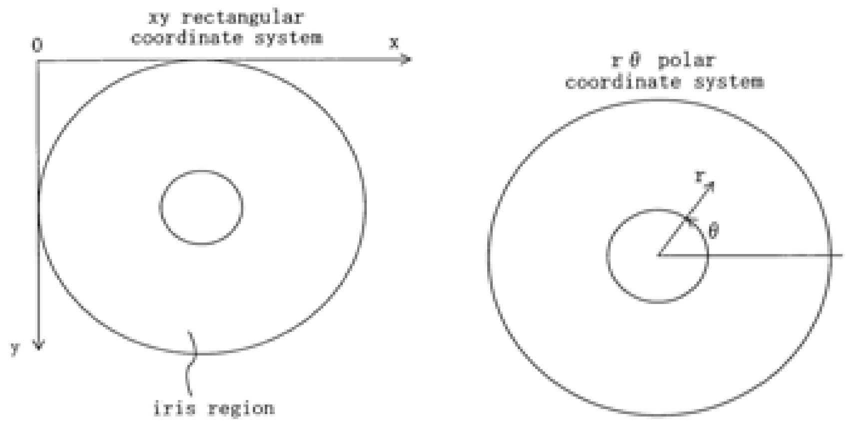

Figure 12: Iris image over a rectangular and polar coordinate systems

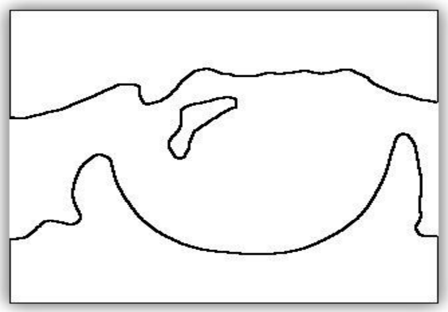

Figure 13: An example of an image that is obtained by intelligently thresholding the original input image and then using Sober to edge detect

This image represents the data that is used to locate the iris; the data is used by the Hough Transform to decide on a best-fit circle to represent the location of the iris. A rough semi-circle can be made out by the human eye; this is what allows the Hough Transform to accurately locate the iris.

The Hough transform is very efficient for the task of finding the iris from an image such as this because it is resilient to noise and performs well even when a large amount of the circle is hidden. For example, when two eye lids are covering a large portion of the iris, as shown in Figure 14.

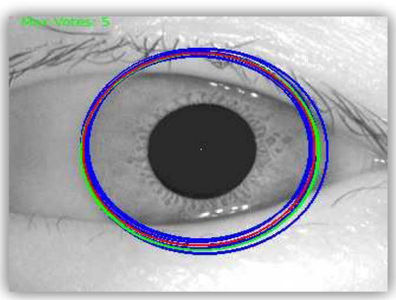

Figure 14: A demonstration of the results obtained by applying the Hough Transform to an image such as that in Figure 13

This provides us with a circle that defines the iris, although portions of this are still obscured by the eyelids, meaning that these also need to be defined.

D. Multi-scale 2-D Gabor Transformation

The iris is encoded to a unique set of 2048 bits which serve as the fundamental identification of that person's particular iris. These iris bit codes can be stored in a database and then compared to uniquely identify a person. The size of 2048 is sufficiently large to store the data of several particular filters on most angles of the iris, while also being sufficiently small to be easily stored in a database and manipulated quickly. We wish to extract phase information from the iris as opposed to amplitude information since phase information is not skewed by pupil deformation.

Figure 15 shows the four phase quadrants and the corresponding bit sequences they represent,

$$h\{R_e, \mathrm{Im}\} = \mathrm{sgn}\{R_e, I_m\} \int \varphi I(\rho, \varphi) e^{-i\omega(\theta_o - \varphi)} e^{-(r_{o-\rho})^{\frac{2}{a^2 e} \frac{(\theta_o - \varphi)^2}{\beta^2}}} \rho d\rho d\varphi \tag{6}$$

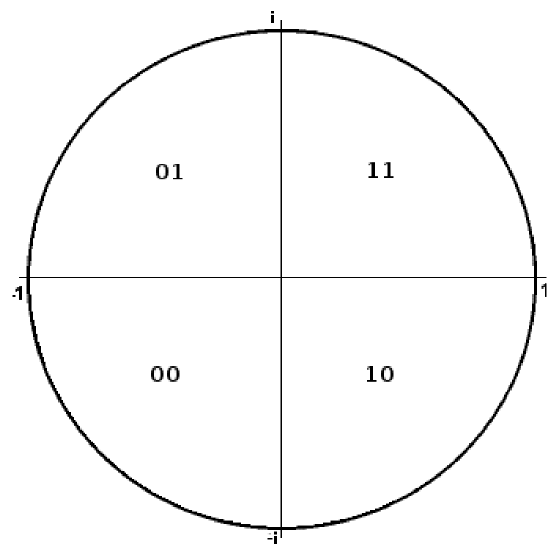

Figure 15: Four phase quadrants and the corresponding bit sequences they represent

Gabor filters have been employed to extract this phase information as suggested by Daugman (2003) [12]. The Gabor filter is an application of the Gabor wavelet (see equation 6) [12]. This will return two bits depending on which quadrant (see Figure 5) the normalized resulting imaginary number from this lies in.

This equation can be simplified for computation by considering it as a combination of two filters: one filter representing the real part of the integral and the other representing the imaginary part. Each of these filters consists of a combination of a Gaussian and a sinusoidal filter. The parameters α, β and γ are then tuned by constraining the Gaussian filter to range over one standard deviation and the sinusoidal filter to range from -π to π.

E. Binarize the Real Part and Imaginary Part of the Gabor Transformed Data to Generate an Iris Code

To provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made [9,10] which is shown in Figure 16.

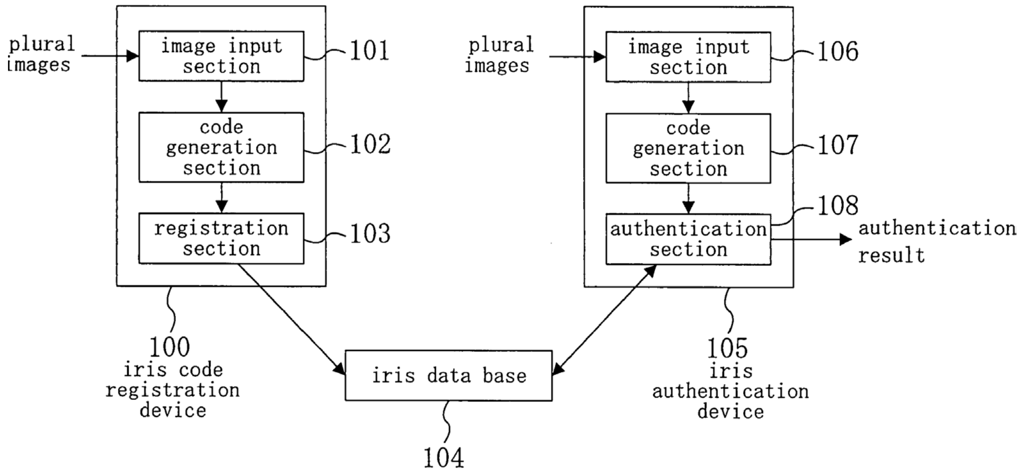

Figure 16: Structures of an iris code registration device and an iris authentication device according to each embodiment of the present invention

Gabor filters are able to provide optimum conjoint representation of a signal in space and spatial frequency. A Gabor filter is constructed by modulating a sine/cosine wave with a Gaussian. This is able to provide the optimum conjoint localization in both space and frequency, since a sine wave is perfectly localized in frequency, but not localized in space. Modulation of the sine with a Gaussian provides localization in space, though with loss of localization in frequency. Decomposition of a signal is accomplished using a quadrature pair of Gabor filters, with a real part specified by a cosine modulated by a Gaussian, and an imaginary part specified by a sine modulated by a Gaussian. The real and imaginary filters are also known as the even symmetric and odd symmetric components respectively [17]. The center frequency of the filter is specified by the frequency of the sine/cosine wave, and the bandwidth is specified by the Gaussian width. In general, Gabor filters are traditional choice, where they suffer from two main limitations: the maximum bandwidth is limited to approximately one octave and they are not optimal if one is seeking broad spectral information with maximal spatial localization. An alternative to the Gabor filter is the log-Gabor filter [17].

The Gabor filters need to be placed so that they take account for a large enough range of data without missing out the fine detail within the iris. As we require 2 bits to uniquely identify each quadrature, we have the additional constraint that 1024 filters must be used, allowing a manageable bit code length of 256B for each iris which can be split into sections of 4B. To simplify the calculations involved in applying the filters to the unwrapped iris they can also be considered to all be placed at a uniform rotation of 0. Since it can be observed that there is a consistent amount of information at points varying in the angular direction in the iris, it is also a good idea to place the filters uniformly in this direction. In this implementation 256 angular directions were considered because it divides our required number of filters evenly and includes a large spread of data across the iris. However, in many cases, in the radial direction there is more distinct information observed closer to the pupil. To include the more important data close to the pupil the filters can be positioned so that a larger proportion of them have their centers in this range. With the 256 angular directions there are 4 radial filter locations left to position. These can be placed uniformly between the bottom of the iris and half-way across the iris to allow the data around the pupil to be explored. Finally, to make sure that filters are always large enough to represent enough data, the constraint that a filter centre cannot be placed on the 3 pixels nearest the top and bottom of the image is added. This means that useless filters of sizes 1 and 3 will never be included when encoding the iris, and we avoid including additional pupil debris that may have been incorporated into the iris section. The final set of filter locations across an unwrapped iris is represented in Figure 17.

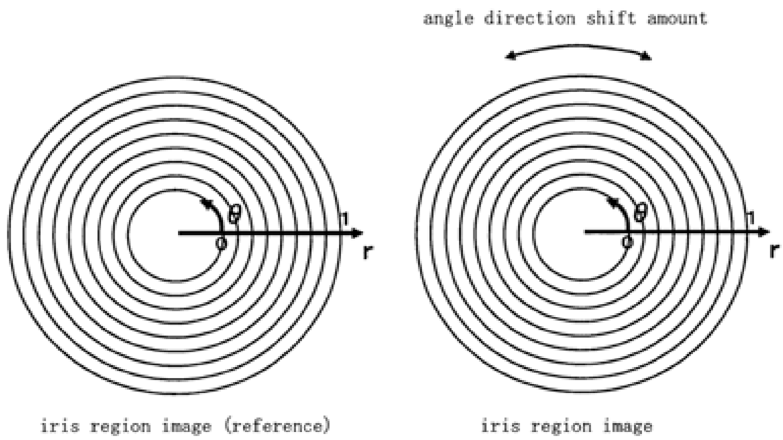

Figure 17: Method of rotationally compensating a Gabor transformed data

F. A Personal Authentication Method using an Iris Image

The steps performed in authentication process are given below and the same is shown in Figure 18.

- **At a time of registration:** Generate an iris code from an iris image; and registering the generated iris code in a database,
- **At a time of authentication:** Generating an iris code from an iris image; and performing authentication by comparing the thus generated iris code with the iris code registered in the database.

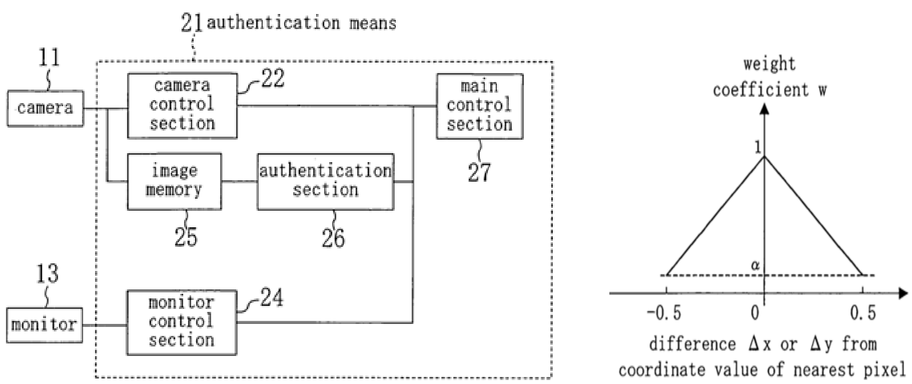

Figure 18: Iris Authentication method

5. CONCLUSION

The proposed system is tested on iris images obtained from version-1 of CASIA database. The simulation results were obtained using Matlab-2009 a software on a personal computer of a dual core processor of 3.07GHz/3MB cache; 2MB RAM (random access memory), and Microsoft windows-XP service pack (2) operating system.

Iris localization using Hough transform performs better as compared to other localization techniques in case of occlusion due to eyelids and eyelashes. The detection of eyelid boundary fails in case of images taken under intensive light conditions. Thus the image of iris should be taken under controlled lightening and illumination condition.

Tables 1 and 2 present the computed hamming distances of ten different irises segmented form ten gray scale images selected randomly from version-1 of CASIA database with and without eyelashes using morphological based iris segmentation method. On the other hand, Tables 3 and 4 present the hamming distances of the same dataset using CHT based method.

In Tables 1 to 4, 1-1 means first row iris image with first column image distance is calculated 1-2 means first row iris image with second column image distance is calculated. If the hamming distance value is 0.0 that is best close and iris recognized. If the hamming distance value is 1.0 that is mismatch and difficult to recognize. These are smart computing methods.

From Tables 1 to 4, it can be inferred that Circular Hough Transform (CHT) is much better than using morphological techniques; where in CHT is based on statistical voting criteria (curve fitting). On the other hand, CHT is much faster than the morphological based methods. HD using morphological method with eyelashes Iris Moreover, the hamming distances obtained from an iris with eyelashes is more accurate than obtained after removing eyelashes; in which the removal of eyelashes causes discarding a large portion of the human iris. In addition, the eyelashes distribution may be viewed as a human-eye-print.

Table 1
HD using morphological method with eyelashes

Iris	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	0	0.47	0.43	0.44	0.44	0.38	0.40	0.3	0.45	0.4
2	0.47	0	0.40	0.38	0.43	0.38	0.40	0.15	0.44	0.4
3	0.43	0.40	0	0.45	0.47	0.42	0.43	0.32	0.43	0.4
4	0.44	0.38	0.45	0	0.43	0.45	0.46	0.16	0.44	0.4
5	0.44	0.43	0.47	0.43	0	0.37	0.40	0.16	0.44	0.4
6	0.38	0.38	0.42	0.45	0.37	0	0.38	0.14	0.33	0.4
7	0.40	0.40	0.43	0.46	0.40	0.38	0	0.25	0.42	0.4
8	0.3	0.15	0.32	0.16	0.16	0.14	0.25	0	0.5	0.2
9	0.45	0.44	0.43	0.44	0.44	0.33	0.42	0.5	0	0.4
10	0.43	0.41	0.43	0.45	0.45	0.41	0.42	0.25	0.39	0

Table 2
HD using morphological method without eyelashes

Iris	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	0	0.4	0.219	0.377	0.363	0.359	0.321	0.3	0	0.345
2	0.4	0	0.385	0.457	0.328	0.405	0.405	0.159	0.273	0.386
3	0.21	0.385	0	0.428	0.36	0.353	0.384	0.325	0.227	0.394
4	0.37	0.457	0.428	0	0.402	0.379	0.438	0.2	0.333	0.289
5	0.36	0.328	0.36	0.402	0	0.313	0.278	0.167	0.388	0.349
6	0.35	0.405	0.353	0.379	0.313	0	0.237	0.2	0.278	0.431
7	0.32	0.405	0.384	0.438	0.278	0.237	0	0.267	0.369	0.386
8	0.3	0.159	0.325	0.2	0.167	0.2	0.267	0	0.5	0.25
9	0.21	0.273	0.227	0.333	0.388	0.278	0.369	0.5	0	0.348
10	0.34	0.386	0.394	0.289	0.349	0.431	0.386	0.25	0.348	0

Table 3
HD using CHT method with eyelashes

Iris	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	0	0.46	0.45	0.32	0.42	0.47	0.45	0.26	0.45	0.46
2	0.46	0	0.46	0.43	0.46	0.42	0.47	0.48	0.45	0.37
3	0.45	0.46	0	0.27	0.43	0.45	0.43	0.43	0.40	0.47
4	0.39	0.43	0.27	0	0.44	0.44	0.43	0.43	0.35	0.43
5	0.42	0.46	0.43	0.44	0	0.44	0.44	0.45	0.39	0.45
6	0.47	0.42	0.45	0.44	0.44	0	0.36	0.40	0.42	0.45
7	0.45	0.47	0.43	0.43	0.44	0.36	0	0.45	0.37	0.45
8	0.26	0.48	0.43	0.43	0.45	0.40	0.45	0	0.41	0.46
9	0.45	0.45	0.40	0.35	0.39	0.42	0.37	0.41	0	0.44
10	0.46	0.37	0.47	0.43	0.45	0.45	0.45	0.46	0.44	0

Table 4
HD using CHT method without eyelashes

Iris	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	0	0.46	0.40	0.37	0.45	0.42	0.42	0.11	0.46	0.45
2	0.46	0	0.40	0.41	0.44	0.40	0.44	0.43	0.45	0.26
3	0.40	0.40	0	0.23	0.43	0.46	0.41	0.40	0.40	0.44
4	0.37	0.41	0.23	0	0.42	0.41	0.42	0.41	0.37	0.41
5	0.45	0.44	0.43	0.42	0	0.43	0.44	0.45	0.41	0.40
6	0.42	0.40	0.46	0.41	0.43	0	0.43	0.42	0.40	0.41
7	0.42	0.44	0.41	0.42	0.44	0.43	0	0.45	0.46	0.45
8	0.11	0.43	0.40	0.40	0.45	0.42	0.45	0	0.42	0.45
9	0.46	0.45	0.40	0.36	0.41	0.40	0.46	0.42	0	0.46
10	0.45	0.26	0.44	0.41	0.40	0.41	0.45	0.45	0.46	0

Due to, the large processing steps in morphological operators based techniques; simple operations (dilation and erosion) and complex operations (closing and opening), morphological techniques may cause boundary distortions of the detected pupils and irises of the eye image. Therefore, the detected pupil and iris may slightly deviate from pure circles.

Hence, the results obtained from CHT are more accurate than those obtained from morphological operations.

6. SUMMARY

In recent days many inventions are being made that are changing the way majority of the individuals lead their lives, and biometric authentication is one such exciting invention that is poised to change the way human beings perceive the world.

The literature review has served to expand the concepts behind biometric authentication, give explanations of how such systems work and to estimate their effectiveness. The point is not to support the reader with deep knowledge of the main physiological biometrics: fingerprint, hand geometry, facial recognition, and iris recognition, but rather to show how these biometrics are surprisingly alike in design. They all function and mainly use of the same techniques.

With the biometric authentication very high reliability and confidence can be expected and the proposed system is usefull in rapid and automatic identification of persons, with very high reliability and confidence levels. Each individual have a unique and stable iris for his eye over a period of many years and such an iris is used in this paper as an optical fingerprint having highly detailed pattern. For conducting various experiments a huge amount of data was required and CASIA iris image database [http://sinobiometrics.com/casiairis.h] has been used. In the process of IRIS methodology to remove noise for better results a median filter technique is used.

For edge detection the Sobel filter is employed which calculates the gradients (in both the x and y direction) of an image based on it's intensity for each pixel. We have also used the Hough Transform method for edge detection and 2-D Gabor transformation for IRIS code generation. Live video image of a person's face having an iris will be founded using image analysis algorithm and it's textue is encoded into a compact form or "iris code".

Analysis by a self-similar set of quadrature (2-D Gabor) band-pass filters defined in a dimensionless polar coordinate system is used for extracting Iris texture from the image at multiple scales of analysis. Projecting many different parts of the iris onto these multi-scale quadrature features determines each bit in an abstracy(256-byte) iris code.

The principle forms of variation in the population of irises is studied and on that degrees-of-freedom in this code are based. Iris codes are present in universal mathematical format and are of constant length, comparisions between them can be readily implemented by the Exclusive-Or(XOR) logical operation.

By the combination of special signal processing methods with statistical decision theory, which leads to statistical test of independence based on a similarity measure(The Hamming code or distance) which can be computed from the Exclusice-Or (XOR) of any two iris codes. This measure can be used for positively establishing in conformation or non conformation of the identity of any individual.

It also generates an objective confidence level associated with any such identification decision. From overall study, it can be concluded that Circular Hough Transform (CHT) is much better than using morphological techniques; where in CHT is based on statistical voting criteria (curve fitting). On the other hand, CHT is much faster than the morphological based methods.

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