Iris Recognition Methods – Survey

Seema
M.Tech(ECE),NCCE, Israna, Panipat, Haryana, India.

Deepti Jaglan
Assistant Professor, NCCE, Israna, Panipat, Haryana, India.

Abstract – The premise is that a biometric is a measurable physical characteristic which are reliable than passwords. Iris biometry is used to recognize an individual in a natural and intuitive way. Secure communications and mobile commerce are some of the application areas. Iris based security applications thrive on infrared cameras and video cameras for logins and transaction authentications. Accuracy, algorithm speed and template size are attributes that are important for large-scale identity programs and national database applications. In this paper, different iris recognition methods which aid an appropriate outlook for future work to build integrated classifier on latest input devices for excellent business transactions are discussed. Benchmark databases, products are also discussed. Since the area is currently one of the most on the go and the bulk of research is very large, this survey covers some of the significant methods.

Index Terms – Iris Recognition, Phase based method, Texture-analysis, Zero crossing, Local intensity variations, Independent Component Analysis, Continuous Dynamic Programming.

1. INTRODUCTION

Biometrics offers with computerized methods of recognizing a character based on physiological characteristics consisting of face, fingerprints, hand geometry, iris, retinal, and vein. Biometric authentication technique based totally on iris styles is suitable for excessive degree protection systems. Iris is the annular ring among the pupil and the sclera of the attention. The shape of iris is constant from approximately one year in age and remains constant over time. It famous long-term stability and infrequent re-enrolment necessities. The variations within the grey degree depth values distinguish people. The distinction exists among identical twins and even between left and right eye of the equal character. As the era is iris pattern-structured, no longer sight structured, it could be used by blind humans. The iris is extraordinarily protected, non-invasive and perfect for coping with applications requiring control of huge person groups, like voter ID control. The iris popularity techniques doubtlessly prevent unauthorized get entry to to ATMs, mobile telephones, computer PCs, workstations, buildings and pc networks. The accuracy of iris popularity structures is established to be lots higher in comparison to different types of biometric structures like fingerprint, handprint and voice print. In the year 1885, a French ophthalmologist, Alphonse Bertillon first proposed iris sample as a foundation for private identification [1]. In 1987,

Flom and Safir [2] acquired an unimplemented concept of automated iris biometrics device. A file turned into published by using Johnston [3] in 1992 with none experimental results. Iris based totally protection systems capture iris patterns of individuals and fit those styles towards the file in available databases. Even though substantial development has been made in iris popularity, dealing with noisy and degraded iris pictures require in addition research. The iris popularity algorithms want to be evolved and tested in various surroundings and configurations. Research problems are based totally on iris localization, nonlinear normalization, occlusion, segmentation, liveness detection and large scale identity. It is needed to attain lowest false rejection rate and fastest composite time for template introduction and matching. A standard iris popularity device involves four main modules.

The first module, photograph acquisition deals with capturing collection of iris images from the concern using cameras and sensors. A picture acquisition consists of illumination, function and physical capture device. The occlusion, lighting fixtures, quantity of pixels on the iris are factors that affect the photograph great [4]. Many iris recognition structures require stern cooperation of the user for photo acquisition. Ketchantang [5] proposed a way in which the complete sequence of picture is received in the course of enrolment and the great possible images are selected, to increase flexibility. Enrolment aids to provide robust identity management.

The 2nd module, pre processing entails diverse steps including iris liveness detection, pupil and iris boundary detection, eyelid detection and removal and normalization. Iris liveness detection differentiates stay subject from a picture, a video playback, a glass eye or other artifacts. It is possible that biometric features are cast and illegally used. Several methods like Hough transformation, integro differential operator, gradient based totally aspect detection are used to localize the quantities of iris and the scholar from the eye photo. The contours of higher and decrease eyelids are match using the parabolic arcs resulting the eyelid detection and elimination. It is essential to map the extracted iris region to a normalized shape. The iris localization methods are primarily based on spring pressure, morphological operators, gradient, possibility and moments. Iris localization technique developed through Zhaofeng He [6] is primarily based on spring pressure-pushed

new release scheme the usage of Hooke's law. The composition of forces from all points determines the centre and radius of student and iris. Morphological operators had been implemented by means of Mira and Mayer [7] to reap iris limitations. The inner boundary is detected with the aid of making use of threshold, picture starting and ultimate operators. The outer boundary is detected by way of applying threshold, ultimate and opening operators. The iris localization method by means of Guodong Guo [8] is based totally on depth gradient and texture difference. The depth gradient use integrodifferential operator. The Kullback-Leibler divergence is used to measure the distance among two chance distributions derived from the internal and outer zones. H. Proenca and L.A.Alexandre [9] proposed a second-primarily based texture segmentation set of rules, the usage of 2nd order geometric moments of the image as texture features. The clustering algorithms like self-organizing maps, ok-means and fuzzy okay-approach were used to phase the photograph to produce as output the clusters-categorised pictures. The experiments have been performed on UBIRIS database with accuracy of ninety eight.02% and ninety seven.88% for images captured in session 1 and consultation 2, respectively. The segmentation performance for 1214 top nice photographs and 663 noisy pictures become 98.02% and 97.88%, respectively.

The 3rd module, function extraction identifies the most distinguished capabilities for type. Some of the capabilities are x-y coordinates, radius, shape and length of the scholar, depth values, orientation of the scholar ellipse and ratio among common intensity of scholars. The capabilities are encoded to a layout appropriate for popularity.

The fourth module, recognition achieves result by way of evaluation of capabilities with saved patterns [10]. The inter-magnificence and intra-elegance variability are used as metrics for sample type troubles.
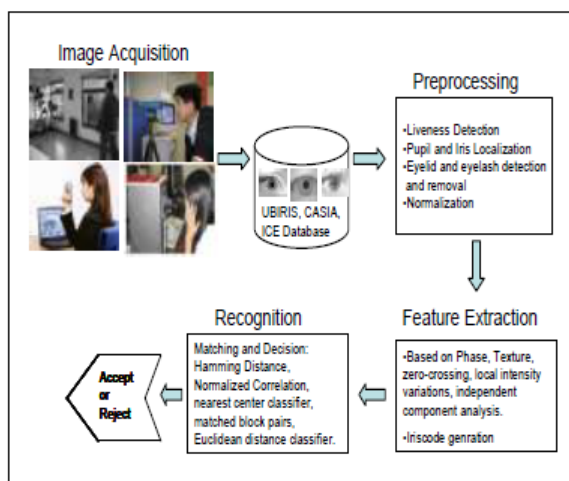

Figure 1: Iris Recognition System

2. IRIS IMAGE DATASETS

The accuracy of the iris popularity device depends on the image quality of the iris photographs. Noisy and low quality images degrade the overall performance of the gadget. UBIRIS database is the publicly to be had database [9]. It consists of photographs with noise, with and without cooperation from subjects. The UBIRIS database has variations with pictures gathered in two awesome sessions corresponding to enrolment and recognition ranges. The 2d model photographs had been captured with greater sensible noise elements on non-restrained situations such as at-a-distance, on-the-pass and seen wavelength. CASIA iris photograph database snap shots are captured in periods [29]. CASIA-IrisV3 contains a complete of 22,051 iris images from greater than 700 subjects. It additionally is composed of twins' iris photo dataset. ND 2004-2005 database is the superset of Iris Challenge Evaluation (ICE) dataset, uses an Iridian iris imaging machine for capturing the images [16]. The machine gives voice feedback to guide the consumer to the best position. The images are obtained in companies of 3 called as shot. For every shot, the device mechanically selects the quality image of the three and reviews values of great metrics and segmentation results for that image. For every person, the left eye and right eye are enrolled one at a time. The specifications of databases are listed in Table 1.

3. IRIS RECOGNITION METHODS

3.1 Phase-based method

The phase based totally technique recognize iris patterns based totally on phase statistics. Phase facts is impartial of imaging evaluation and illumination. J. Daugman [11, 12] designed and patented the first whole, commercially to be had segment-based totally iris popularity system in 1994. The eye images with decision of 80-130 pixels iris radius have been captured with image focus evaluation performed in real time. The student and iris boundary was located using integrodifferential operator given in Equation (1).

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \int \frac{I(x,y)}{2\pi r} \, ds \right| \qquad (1)$$

where I(x,y) is the image in spatial coordinates, r is the radius, (x_0,y_0) are centre coordinates, the symbol * denotes convolution and $G_\sigma(r)$ is a Gaussian smoothing feature of scale σ. . The centre coordinates and radius are envisioned for both student and iris by figuring out the most partial by-product of the contour fundamental of the photo along the round arc. The eyelid boundaries are localized through changing the direction of contour integration from round to arcuate. The iris portion of the photo I(x, y) is normalized to the polar shape through the mapping function $I(x(r, \theta), y(r, \theta)) \rightarrow I(r, \theta)$ wherein r lies on the unit c program language period [0,1] and θ is the angular amount inside the variety [0,2π]. The representation of iris texture is binary coded through quantizing the phase reaction

of a texture filter using quadrature 2D Gabor wavelets into 4 degrees. Each pixel inside the normalised iris sample corresponds to 2 bits of records in the iris template. A general of two,048 bits are calculated for the template, and an equal variety of masking bits are generated so that it will masks out corrupted areas in the iris. This creates a compact 256- byte template, which lets in for storage and assessment of iris. The popularity in this technique is the failure of a check of statistical independence regarding levels of freedom. Iris codes are distinct for two unique samples. The check changed into executed using Boolean XOR operator applied to 2048 bit phase vectors to encode any two iris patterns, masked by using each of their corresponding mask bit vectors. From the resultant bit vector and masks bit vectors, the dissimilarity degree among any two iris styles is computed using Hamming Distance (HD) given in Equation (2).

$$HD = \frac{|(code\ A \otimes code\ B) \cap maskA \cap maskB|}{|maskA \cap maskB|} \qquad (2)$$

Where code A, code B are two phase code bit vectors and mask A, mask B are mask bit vectors. The HD is a fractional measure of dissimilarity with 0 representing a perfect match. A low normalized HD implies strong similarity of iris codes. The work by Xianchao Qui [13] used 2D Gabor filters for localization. The filter response vectors were clustered using vector quantization algorithms like k-means. The experiments International Journal of Computer Applications (0975 – 8887) Volume 3 – No.5, June 2010 22 were conducted on CASIA-Bio secure iris database consisting of images captured from Asian and non-Asian race groups. The support vector machine was used for the two class ethnic classification. The methodology proposed by Martin-Roche [14] and Masek [15] operates in the same concept of Daugman for recognition. In Martin's method, the iris circumference parameters are obtained by maximising the average intensity differences of the five consecutive circumferences. In Masek's method, the segmentation was based on the Hough transform. The phase data from 1D Log-Gabor filters was extracted and quantised to four method, such bits called as the fragile bits are identified and masked to improve the accuracy. The signal-level fusion method uses image averaging of selected frames from a video clip of an iris. Local texture distortions occurs with contact lenses with a logo, poor-fit contacts and edges of hard contact lenses, segmentation inaccuracies and shadows on the iris. These are detected by analysing iris code matching results. The 20x240 normalized images were covered with 92 windows each of size 8x20. Fractional HD was computed for each window. The location of windows with highest fractional HD was identified and removed from further calculations. The effect of dilation was studied by collecting datasets of images with varying degrees of dilation. The data was divided into subsets with small pupils, medium pupils and large pupils. The subset of data with large pupils showed worst performance with EER at an order of magnitude greater compared to that of small pupil data set. The visibility in the iris area is reduced and greater part of iris is occluded by eyelids which provide less information for iris code generation.

Table 1: Database specifications

Database	Research Lab	Version	Camera used for image acquisition	Images	Subjects	Format	Resolution
UBIRIS	SOCIA Lab. – Soft Computing and Image Analysis Group, Department of Computer Science, University of Beira Interior, Portugal	V1	Nikon E5700 camera	1877	241	jpeg	400x300
		V2	Canon EOS 5D	11,102	261	jPEG	800x600
CASIA	Iris Recognition Research Group, Centre for Biometrics and Security Research, National Laboratory of Pattern Recognition, Institute of Automation, Chinese Academy of Sciences, Beijing, China.	V1	Self-developed	756	108	bmp	320x280
		V2	Self-developed	1200	60	bmp	640x480
		V3-Interval	Self-developed	2655	249	jpeg	320x280
		V3-lamp	OKI	16213	411	jpeg	640x480

		V3-Twins	OKI	3183	200	jpeg	640x480
ND 2004-2005	Dept. of Computer Science and Engineering, University of Notre Dame, Notre Dame, United States of America	-	Iridian LG EOU2200	64,980	356	tiff	640x480
University of Bath Iris Image Database	University of Bath, Bath, United Kingdom	Iris DB 400	AD-100 Iris Guard Dual Eye autofocus camera	8,000	200	bmp	1280 x 960
		Iris DB 800		16,000	400	bmp	1280 x 960
		Iris DB 1600		32,000	800	bmp	1280 x 960
UPOL	Dept. Computer Science, Palacky University, Olomouc	-	SONY DXC-950P 3CCD camera	384	64	png	576x768

3.2 Texture-analysis based method

Wildes proposed iris reputation based totally on texture analysis [18,19, 20]. High best iris photos was captured the use of silicon intensified goal digicam coupled with a well known frame grabber and resolution of 512x480 pixels. The limbus and student are modelled with round contours which is prolonged to higher and decrease eyelids with parabolic arcs. The particular contour parameter values x, y and radius r are received with the aid of the vote casting of the brink points the use of Hough transformation. The biggest wide variety of facet factors represents the contour of the iris. The Laplacian of Gaussian (Log) is carried out to the picture at more than one scales and Laplacian pyramid is built. The Log filter out is given in Equation (3).

$$-\frac{1}{\pi\sigma^4}\{1 - \frac{\rho^2}{2\sigma^2}\}e^{\rho^2} \ /2\sigma^2 \qquad (3)$$

in which σ is the standard deviation of the Gaussian and ρ is the radial distance of a factor from the filter out's centre. The matching is based on normalised correlation between the obtained and database pictures. Classification is executed using Fisher's linear discriminant characteristic. The technique for iris identity through Emine Krichen [21] use a hybrid approach for iris segmentation, Hough remodel for outer iris boundary and integro differential operator for internal iris boundary. The iris code became produced the use of wavelet packets. The complete photograph is analyzed at distinctive resolutions. 832 wavelets with 4 scales are used to generate 1664 bits code. The iris database consisted of seven hundred picture acquired with seen light. An improvement of two% FAR and 11.5% FRR became obtained relative to Daugman approach. It changed into determined that by way of considering colour records, general improvement of 2% to 10% turned into acquired in line with threshold price.

3.3 Zero- Crossing representation method

The technique developed through Boles [22] represents capabilities of the iris at distinct decision tiers based on the wavelet remodel zero-crossing. The set of rules is translation, rotation and scale invariant. The input snap shots are processed to obtain a set of 1D signals and its 0 crossing illustration based totally on its dyadic wavelet transform. The wavelet function is the first derivative of the cubic spline. The centre and diameter of the iris is calculated from the brink-detected image. The digital circles are built from the centre and stored as circular buffers. The records extracted from any of the digital circles is normalised to have same range of information factors and a zero crossing representation is generated. The representation is periodic and independent from the place to begin on iris virtual circles. These are stored within the database as iris signatures.

The dissimilarity between the iris of the same eye snap shots became smaller compared to the eye images of one of a kind eyes. The gain of this function is that the quantity of computation is reduced on the grounds that the amount of 0 crossings is less than the wide variety of facts points. But the downside is that it calls for the in comparison representations to have the identical number of 0 crossings at every resolution level.

3.4 Approach based on intensity variations

Iris reputation gadget advanced by means of Li Ma is characterized via neighbourhood intensity variations [10]. The sharp variation points of iris patterns are recorded as functions. In the iris localization section, the centre coordinates of the pupil are envisioned through image projections in horizontal and vertical guidelines. The genuine parameters of the scholar and iris circles are calculated the use of Canny side detection operator and Hough transform. The iris in cartesian coordinate gadget is projected into a doubly dimensionless pseudo polar coordinate system. The nearby spatial patterns in an iris encompass frequency and orientation records. Gabor filters are built to gather frequency band in the spatial area. Gabor capabilities are Gaussians modulated by way of circularly symmetric sinusoidal capabilities. The feature extraction starts off evolved by way of generating 1D intensity alerts considering the facts density inside the angular path. The 1D signal is represented using dyadic wavelet remodel to gain the characteristic vector. It decomposes the sign into element additives at exclusive scales. The feature values are the suggest and the average absolute deviation of the importance of each 8x8 block within the filtered photograph with the entire variety of blocks being 768. For dimensionality discount, Fisher Linear Discriminant is used and for class, nearest centre classifier is used. The similarity among the pair of feature vectors is calculated using the XOR operation. The circular shift-based matching is achieved from which the minimal matching rating is taken into consideration after several round shifts. Alternatively, Li Ma proposed the orthogonal second based totally technique [23] wherein the Gauss-Hermite moments of 1D indicators are used as distinguishing features. These moments are powerful to signify the local information of the sign. Ten depth indicators had been generated and 4 exclusive order (1-four) moments had been used. The function vector become built through concatenating those functions. The nearest centre classifier primarily based on cosine similarity degree changed into adopted for classification in a low dimensional feature area. The approach by means of Li Ma became further improved by way of Zhenan Sun [24] wherein in the nearby function based totally classifier was mixed with an iris blob matcher. The blob matching geared toward finding the spatial correspondences between the blocks inside the input picture and that inside the stored model. The similarity is primarily based at the number of matched block pairs. The block attributes are recorded as centroid coordinates area and

2d order principal moments. The technique by means of Jong Gook Ko [25] is primarily based on cumulative-sum-based totally exchange factors. The iris segmentation uses Daugman's technique and the segmented photograph is normalized to 64x300 pixel region. The feature extraction is executed the usage of cumulative sums on businesses of basic cells wherein each cell is of size 3x10. An common grey value represents the cell place for calculation. The cellular areas are grouped horizontally and vertically and cumulative sums are calculated over each group. The iris feature codes are generated primarily based on the sum in both horizontal and vertical directions. The maximum and minimal of the sum is calculated. For the summation values that lie between these two values, if the sum is on upward slope the cell's iris code is about to 1. When the sum is at the downward slope, the mobile's iris code is set to 2 in any other case cellular's iris code is set to zero. Matching is executed the usage of HD. A vicinity-based feature extraction method based on 2D-Discrete Wavelet Transform changed into proposed via N.Tajbakhsh [26]. The iris texture is partitioned into 32x32 pixel blocks and then the 2D wavelet decomposition is performed on each block. The Gauss-Laguerre clear out is used to generate a binary matrix similar to iris code in Daugman approach.

3.5 Approach using Independent Component Analysis

The iris recognition gadget advanced by means of Ya-Ping Huang [27] adopts Independent Component Analysis (ICA) to extract iris texture features. Image acquisition is completed at distinct illumination and noise levels. The iris localization is executed using integrodifferential operator and parabolic curve fitting. From the inner to outer boundary of iris, fixed variety of concentric circles n with m samples on each circle is acquired. This is represented as a matrix n x m for a particular iris image that's invariant to rotation and size. The unbiased components are uncorrelated, decided from the characteristic coefficients. The function coefficients are non-Gaussian and together independent. The basis function used is kurtosis. The unbiased components are expected and encoded. The centre of every class is determined through competitive mastering mechanism that is stored as the iris code for a person. The average Euclidean distance classifier is used to recognize iris patterns.

3.6 Iris authentication based on Continuous Dynamic Programming

The technique proposed by using Radhika [28] authenticates iris based totally on kinematic characteristics, acceleration. Pupil extraction begins by means of identifying the very best top from the histogram which provides the threshold for lower intensity values of the eye photograph. All the related additives in pattern eye image much less than threshold intensity cost are labelled. By selecting the maximum place component we arrive at student region of the eye. Normalised bounding rectangle is implemented using centre of scholar to crop iris. Continuous

dynamic programming is used with the idea of evaluating form characteristics component sensible. The acceleration plot is segmented and components of acceleration curve are used to affirm with enter's acceleration curve. For iris samples, price of change of grey level intensities within bounding container bureaucracy acceleration function plot. The implementation is based the concept of gathered minimal nearby distances between a reference template and input pattern. The reference template is received using go away one out technique. The distance degree is the rely of directional changes in acceleration plot. The neighbourhood distances are directional modifications in respective segmented slots of the acceleration plot. The methods are summarized in Table 2.

Table 2. Iris Recognition Methodologies

Group	Size of Database	Results
Daugman	4258 images	EER: 0.08%.
Wildes et al. Boles and Boashash	60 images Real images	EER: 1.76% EER: 8.13%
Li Ma	2245 images (CASIA)	Correct Recognition Rate: 94.33%.
Masek	624 images	FAR: 0.005% FRR: 0.238%.
Ya-Ping Huang	Real images	81.3% for blurred iris, 93.8% for variant illumination and 62.5%for noise interference images.
H. Proenca and L.A.Alexandre	1877 images (UBIRIS)	Recognition rate: 98.02%(session 1), 97.88%(session 2)
Tisse and Martin	300 images	FRR: 8%
Xiaomei Liu	12000 images	Recognition rate: 96.61%

Group	Size of Database	Results
	(ICE)	
Jinyo Zuo	450 images (MMU1)	EER: 0.0256%
Jong Gook Ko et Al	(i) 820 images from 82 individuals (ii) 756 images (CASIA)	FAR: 5.26%, FRR:0.25% Recognition rate: 98.21%
N.Tajbakhsh	1877 images (UBIRIS)	0.66% ERR, 4.10% FRR and 0.01% FAR.
Karen Hollingsworth	(a) 1226 images from 24 subjects (ICE). (b) 1061 videos from 296 eyes. (c) ICE database (d) 1263 images from18 subjects.	(a)HD=7.48 (b)EER=3.88x10-3 FRR=7.61x10-6, FAR=0.001 (c) HD=0.15 (d)FRR=0.271, FAR=0.001, EER=0.068 for large pupil subset

4. PRODUCTS AND SOLUTIONS

Iris authentication products are utilized in widespread packages like civilian identity management applications. Some of the products are as follows. The iris popularity machine through L-1 Identity Solutions is based on Daugman approach. The algorithm has been used within the National Institute of Standards and Technology Iris Exchange [NIST IREX] testing software. The Offender Identification System [Offender-ID] helps identity of prisoners in jail surroundings. PIER 2.4 presents mobile identification with iris technology in a real time surroundings. The Handheld Interagency Identity Detection Equipment [HIIDE] is a multi-biometric hand-held device. It is utilized in protection organizations and in faraway or centralized enrolments. The LG Iris Access, Panasonic BM-ET200, Oki, IBM, Iris Guard IG-AD100, Sagem, Securimetrics and Argus systems paintings by using reading the iris styles and converting them into virtual templates.

5. CONCLUSION

The physiological characteristics are fairly particular to an man or woman. A technique to reliable visual recognition of humans is performed by using iris styles. The other tactics are based on discrete cosine transforms, nook detection and parametric template strategies. The future paintings in real programs usage to aid technology of compact iris codes for mobile telephones and PDAs. In this paper, a try has been made to present an perception of different iris recognition techniques. The survey of the techniques provides a platform for the improvement of the unconventional strategies in this place as destiny work.

REFERENCES

[1] Bertillon. La couleur de Piris. Revue scientifique, Vol. 36, No. 3, pp. 65-73, 1885.

[2] Leonard Flom and Aran Safir, "Iris recognition system", U.S.Patent 1244552, 1987.

[3] R. Johnston, "Can iris patterns be used to identify people?",Los Alamos National Laboratory, Chemical and Laser Sciences Division Annual Report LA-12331-PR, pp. 81-86, 1992.

[4] Kevin W. Bowyer, Karen Hollingsworth, Patrick J. Flynn, "Image Understanding for Iris Biometrics: A Survey, Computer Vision and Image Understanding", Vol. 110, Issue 2, pp. 281- 307, 2008.

[5] W. Ketchantang, S. Derrode, S. Bourennane and L. Martin, "Video Pupil Tracking for Iris Based Identification", Advanced Concepts for Intelligent Vision Systems, LNCS 3708, pp. 1-8, 2005.

[6] Zhaofeng He, Tieniu Tan and Zhenan Sun, "Iris Localization via Pulling and Pushing", International Conference on Pattern Recognition, pp. 366 - 369, 2006.

[7] Mira J. and Mayer J., "Image feature extraction for application of biometric identification of iris: a morphological approach", IEEE Proc. XVI Brazilian Symposium on Computer Graphics and Image Processing, pp. 391- 398, 2003.

[8] Guodong Guo, Micheal J. Jones, "Iris extraction based on Intensity Gradient and Texture Difference", IEEE Workshop on Applications of Computer Vision, pp. 1-6, 2008.

[9] Proenca H, and Alexandre, L.A, "UBIRIS: a noisy iris image database", ICIAP 2005, International Conference on Image Analysis and Processing, pp. 970-977, 2005.

[10] Li Ma, Tieniu Tan, Yunhong Wang, Dexin Zhang, "Personal Identification based on Iris Texture Analysis", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.25, No.12, pp. 1519 – 1533, 2003.

[11] Daugman J, "How iris recognition works", IEEE Transactions CSV, Vol.14, No.1, pp. 21-30, 2004.

[12] J. Daugman, "High Confidence Visual Recognition by a test of Statistical Independence", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 15, No.11, pp.1148-1161,1993.

[13] Xianchao Qui, Zhenan Sun and Tieniu Tan, "Learning Appearance primitives of iris images for ethnic classification", International Conference on Image Processing, pp. 405-408, 2007.

[14] Martin-Roche D., Sanchez-Avila C. and Sanchez-Reillo R., "Iris recognition for biometric identification using dyadic wavelet transform zero-crossing", IEEE Aerosp. Electron. Syst. Mag., Vol. 17, Issue 10, pp. 3-6, 2002

[15] Libor Masek, "Recognition of Human Iris Patterns for Biometric Identification", School of Computer Science and Soft Engineering, The University of Western Australia, 2003.

[16] Xiaomei Liu, Bowyer K.W., Flynn, P.J., "Experimental Evaluation of Iris Recognition", IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, pp. 158-165, 2005.

[17] Karen Hollingsworth, Sarah Baker, Sarah Ring, Kevin W. Bowyer and Patrick J. Flynn, "Recent research results in iris biometrics", Proceedings of the SPIE, Vol. 7306, pp. 73061Y- 73061Y-10, 2009. International Journal of Computer Applications (0975 – 8887) Volume 3 – No.5, June 2010

[18] R. Wildes, J. Asmuth, G. Green, S. Hsu, R. Kolczynski, J. Matey, and S. McBride, "A machine-vision system for iris recognition", Machine Visual Application, Vol. 9, pp. 1-8, 1996.

[19] R. Wildes, "Iris recognition: an emerging biometric technology", IEEE Proceedings, Vol. 85, pp. 1348-1363, 1997.

[20] R.P.Wildes, J.C.Asmuth, G.L. Green, S.C.Hsu, R.J,Kolczynski, J.R.Matey, S.E.McBride, David Sarno_ Res. Center, Princeton, NJ, "A System for Automated Iris Recognition", Proceedings of the Second IEEE Workshop on Applications of Computer Vision, 1994.

[21] Emine Krichen, M.Anouar Mellakh, Sonia Garcia-Salicetti, Bernadette Dorizzi, "Iris identification using Wavelet packets", International Conference on Pattern Recognition, Vol. 4, pp. 335- 38, 2004.

[22] W. W. Boles and B. Boashash , "A Human Identification Technique Using Images of the Iris and Wavelet Transform", IEEE Transactions On Signal Processing, Vol. 46, No. 4, April 1998.

[23] Li Ma, Tieniu Tan, Yunhong Wang, Dexin Zhang, "Efficient Iris Recognition by characterizing Key Local Variations", IEEE Transactions on Image Processing, Vol. 13, No.6, 2004.

[24] Zhenan Sun, Yunhong Wang, Tieniu Tan and Jiali Cui, "Improving Iris Recognition Accuracy Via Cascaded Classifiers", IEEE Transactions on Systems, Man and Cybernetics, Part C, Vol. 35, No. 3, pp. 435-441, 2005.

[25] Jong Gook Ko, Youn Hee Gil, Jang Hee Yoo, Kyo Il Chung,"Method of iris recognition using cumulative-sum-based change point analysis and apparatus using the same", US Patent 20070014438, 2007.

[26] Nima Tajbakhsh, Khashayar Misaghian and Naghmeh Mohammadi Bandari, "A Region-Based iris feature extraction method based on 2D-wavelet transform", Bio_ID_MultiComm2009, LNCS 5707, pp. 301-307, 2009.

[27] Ya-Ping Huang, Si-Wei Luo, En- Yi Chen, "An efficient iris recognition system", International Conference on Machine Learning and Cybernetics, pp. 450-454, 2002.

[28] CASIA-IrisV3, http://www.cbsr.ia.ac.cn/IrisDatabase. Htm