International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 10 (2018) pp. 8728-8735

Review on Iris Recognition Research Directions- A Brief Study

Suleiman Salihu Jauro

Department of Computer Science & Information technology Sam Higginbottom University of Agriculture, Technology & Sciences (SHAUTS), Allahabad 211007, U.P, India.

Raghav Yadav

Department of Computer Science & Information technology Sam Higginbottom University of Agriculture, Technology & Sciences(SHAUTS), Allahabad 211007, U.P, India.

Abstract

The escalating demands of safety measures in the everyday life are more important, biometric recognition has ended up into a sizzling research topic aimed at its potential values in personal recognition since Biometric detection system stands one among that system which stands safer than various other security systems. To automatically recognize and also authenticate person biometric systems employs unique features and characteristics. Since the past decennium researchers are engaging Iris recognition intended for this. Iris region segmentation and also classification are the most contentious problem present inside the iris recognition system since the poor results in these stages will spoil or shatter its effectiveness. Image characteristics, like, the varying pigmentation levels, brightness and also contrast, occlusion by eyelids and/or eyelashes, united with the differing sensor and also environmental circumstances, cause iris segmentation vast additionally a hard task. Therefore, there stands a requirement to discuss the problems of iris recognition to apply a new efficient algorithm. Intend of this given paper is, to review about all the research directions in Iris recognition.

Keywords: Classification; Features; Iris Recognition; segmentation

INTRODUCTION

Individual's authentication has dependably been an appealing objective in computer vision. Authentication frameworks predicated on human attributes, say, face, voice, iris, and finger are known Biometrics applications. The fundamental of numerous biometric applications is to get the input image and produce imperative component vectors like color, texture; and so on nowadays, to offer the safe facilities and also aids to the user the correct identification is essential. Iris Recognition accomplished an incredible consideration in recent times owing to its unique features, for instance, ridges, freckles, rings, furrows together with the complicated pattern. The automated individual identity authentication frameworks grounded upon iris recognition presumed to be the most consistent amongst all biometric strategies: we consider that the chances of discovering two humans with indistinguishable iris pattern just about zero. That is the reason iris recognition technology turning into a critical biometric solution for individual's identification in getting to control as networked access to the computer application. An interior organ that is a fine, round structure secured inside the eye is the iris additionally it aids in controlling the measure of light penetrating the eye.

Need for Iris Recognition System

- The iris authentication stands non-invasive tenable can be engaged for managing an organization.
- Iris comparison along with recognition can be allowable to access the workstations, cellular phone, and machine system on top of ATM.
- Indeed genetically identical persons (moreover the left in addition to right eyes of the same human being) have totally independent iris textures. Also, iris is stable that it is insusceptible to age and environment.

General Structure

Figure 1 indicates a general stream of iris recognition algorithm. The initial phase is to catch the picture through special hardware utilizing built-in megapixel camera. At that point the eye section of the image is isolated and the internal together with external edges of the iris are segmented utilizing complicated image processing algorithms. At that point, the iris present in the isolated eye image is found and segregated it is encoded utilizing mathematical algorithms bringing about a code that holds the unique iris quality. Albeit, any two images at diverse times in addition, in various conditions won't be precisely equivalent and the process can approve whether the iris belongs to that individual or not.

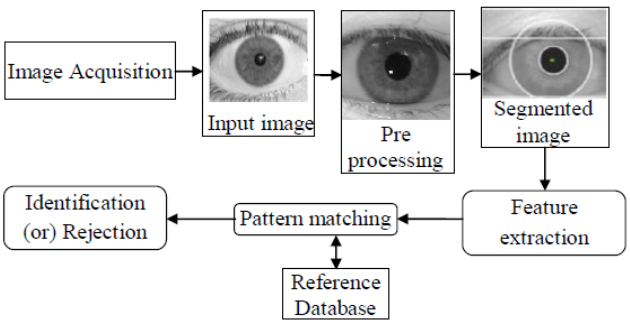


Figure 1: General flow of iris recognition

LITERATURE REVIEW

This stage talks about the distinctive research works, which has been completed in iris recognition field. Table 1 surveys about various methods connected on iris recognition.

Table 1: A glance on different iris recognition techniques

Key Technique	Author name	Description	Limitations
Multimodel approach on iris recognition	Gil Santos and Edmundo Hoyle [1]	New fusion of various iris recognition approaches has been suggested utilizing non-perfect visible-wavelength images caught in an unimpeded environment.	Algorithm assessed utilizing noise-free iris images that doesn't give accurate outcomes.
	Tieniu Tan *et.al* [2]	A viable strategy for visible light iris image coordinating by utilizing different attributes of iris along with eye images proposed.	Less efficient
Feature Extraction	Swathi S. Dhage *et.al* [3]	Flexible Iris Recognition was proposed which used Randon Transform and Top hat filtering. DWT+DCT were utilized for extracting the iris features.	Computational time is high aimed at real time applications.
Neural Network Approach	Kamal Hajari *et.al* [4]	A NN structure was proposed to upgrade the iris recognition performance in noisy condition and furthermore to build the recognition rate	Exact Computation time isn't assessed.
	S. Poornima. *et.al* [5]	Fast and Reliable NN structure was presented centered upon the minimum response time for iris localization.	Integro-differential operator suffers from bright spots of the illumination interior to the pupil.

Nianfeng Liu *et.al* [6] suggested a code-level plan in heterogeneous iris recognition. The non-linear connection betwixt binary elements codes of heterogeneous iris images was demonstrated via an adapted Markov network. Additionally, a weight map on the dependability of binary codes in the iris template can be gotten from the model. Broad exploratory results of matching cross sensor, high-resolution versus low-resolution and, clear versus obscured iris images exhibited that the code-level approach can accomplish the most noteworthy accuracy in contrasted with the current pixel-level, feature level besides score-level solutions.

Sheng-Hsun Hsieh *et.al* [7] recommended a new hardware-software hybrid strategy to build the stand-off distance in an iris recognition framework. When designing the framework hardware, they utilized an improved wavefront coding procedure to expand the field depth. To recompense for the image obscuring caused by wavefront coding, on the software side, the presented framework utilized a local patch centered super-resolution strategy to reestablish the obscured image to its clear variant. The presented framework can expand the catch volume of a regular iris recognition framework by three times and keep up the framework's high recognition rate. But still, attributable to the hardware implementation, the planned model has the downside of high-cost.

Chun-Wei Tan *et.al* [8] researched a promising iris encoding accompanied by a matching system for the noisy iris images obtained at a distance in the company of under less compelled conditions utilizing visible accompanied by NIR imaging. The approach exhibited in their work concurrently exploited the iris features computed from both the computed and worldwide feature portrayals. The supremacy of the projected iris encoding along with coordinating methodology has been decided by furnishing examination with numerous contending iris encoding together with corresponding algorithms on this three freely accessible databases: UBIRIS.v2, CASIA.v4-distance, FRGC, which recommend upgrades of 36.3%, 32.7% and29.6% in equal error rates(EER), individually, as contrasted with a quite few contending approaches. The restriction of their work is, they don't consider the multimodal procedure.

Chun-Wei Tan *et.al* [9] planned a nonlinear way to simultaneously represent both local consistency of iris bit moreover the general qualities of the weight map to stabilize /weight the encoded iris bits. Their approach hence more successfully penalizes the delicate bits while simultaneously remunerating more steady bits in an attempt to attain more stable elements of local iris features, a Zernike moment centered phase encoding of iris features was suggested. A joint methodology was embraced to simultaneously extract and consolidate the global accompanied by the localized iris features. Their experimental results recommended that suggested technique can accomplish huge advancement in iris matching accuracy over those contending approaches i.e., an average advancement of 54.3%, 32.7%, along with 42.6% in EER, individually, aimed at UBIRIS.v2, FRGC, along with CASIA.v4-distance.

Jianxu Chen *et.al* [10] implemented an iris recognition technique intended for identifying corresponding iris crypts

consequently. The proposed matching plan was intended to manage potential topological alterations in the spotting of a similar crypt in various images. Their approach beats the eminent visible-feature centered iris recognition strategy predicated on three distinctive datasets. In particular, their approach accomplished in excess of 22% higher rank one hit rate in the identification, and more than 51% lower EER in verification. Likewise, the benefits of their approach on multi-enlistment was tentatively illustrated. Still substantial occlusion along with terrible illumination have a more extreme effect on their approach than the customary iris code. Poor illumination may bring about low contrast so fewer features can be spotted than under normal illumination.

Zhiyong Peng *et.al* [11] has given an enhanced Daugman iris recognition algorithm that incorporates in two aspects: Improvement intended for iris confinement as well as The improvement intended for iris encoding along with matching algorithms. In Step 1, the localization and shape of the pupil were generally decided in iris image. In Step 2, the conceivable noise from residual eyelashes was additionally separated by choosing a "pure" iris part as a reference and making an approval judgment pixel-wise. The suggested algorithm has an undeniable improvement in boosting the speed accompanied by lessening the dismissal rate.

Imran Naseem et.al [12] introduced the class-specific dictionaries concept aimed at iris recognition. Substantially, a linear combination of training images from every class was the depiction of the query image. The well-conditioned inverse issue was solved utilizing least squares regression in addition the decision was ruled supporting the class which has the utmost accurate estimation. An augmented modular approach was further suggested to oppose noise because of imperfect segmentation of the iris region. The suggested algorithm was contrasted with the newfangled Representation Classification with Bayesian fusion aimed at multiple sectors. the suggested algorithm's complexity analysis demonstrated the decisive excellence of the recommended approach.

Iris Recognition Using Hough Transform

Farmanullah Jan *et.al* [13] have executed a trustworthy iris localization algorithm. They initially confined the coarse site of the iris in the eye image utilizing a robust strategy centered upon the Hough transform along with image gray level insights. Besides, they utilized a solid system including a bi-valued adaptive-threshold predicated upon the Histogram-bisection along with image gray level statistics; Thirdly, they reuse the Hough collector, which was produced for the coarse iris region confinement, additionally the image gray level statistics to robustly localize the limbic limit. At long last, they regularize these limits utilizing a technique centered upon the radial gradient-maxima and the Fourier series. Correlations of the presented procedure with other present-day techniques indicated satisfactory execution.

Zhonghua Lin *et.al* [14] has introduced a pupil site technique grounded on the OTSU strategy and also Hough transform. To start with, it found a half quart in the facula by gray summing operator for guaranteeing the probable territory to find the focal point of the pupil, at that point it picked one channel from R,G along with B these three channels by distribution of histograms of three channels separately to diminish the computing complexity. At that point, an automatic threshold value by OTSU strategy was guaranteed and acquired the binary image. Lastly, in the binary image, it utilized Hough transform in a certain area to fit the pupil edge. Their algorithm achieves 100% at precision. Additionally, it guaranteed the robustness of area.

Iris Recognition using Feature Extraction

Yuniol Alvarez-Betancourt *et.al* [15] introduced a vigorous key points-centered feature extraction framework aimed at iris recognition beneath changeable image quality conditions. Their proposition relied upon the productive fusion of SIFT features' three data sources at matching score level. Three detectors employed to distinguish particular key points: Harris-Laplace, Hessian-Laplace, accompanied by Fast Hessian. Once the three sources were acquired, they were portrayed as far as SIFT features. The proposed fusion rule figures weights, which represent the reliability degree to which every individual source must contribute keeping in mind the end goal to decide the more discriminative matching scores. The disadvantage of this model is the planned feature extraction stage, which is tedious.

Soubhagya Sankar Barpanda *et.al* [16] projected energy centered features utilizing a multi-resolution analysis in iris template. It was predicated upon the recommended triplet half-band filter bank (THFB). The iris template was isolated into six equispaced sub-templates along with two level deterioration was made to every sub-templates utilizing THFB excluding the second one. Accordingly, energy features were gotten from the decayed coefficients of every sub-template. Comparative analysis was performed with already existing features centered upon Gabor transform, CDF 9/7 filter bank, together with Fourier transform. The suggested scheme demonstrated good performance centered upon FAR, GAR along with AUC.

Sirvan Khalighi *et.al* [17] presented a dependable iris recognition method engaging a new scale, shift on top of rotation invariant feature extraction strategy in time-frequency along with spatial domains. To be sure, a 2-level non-subsampled contourlet change (NSCT) was applied on the standardized iris images accompanied by a gray level co-occurrence matrix with 3 distinct orientations was processed on spatial image together with NSCT frequency sub-bands. Besides, the occluded part's impact was lessened by playing out an iris localization algorithm pursued by four regions of interest selection. The extracted feature set was transformed and as well normalized to lessen the impact of extraordinary values in the feature vector. Next, noteworthy features aimed at iris recognition were chosen by means of a two-phase technique created via a filtering phase along with wrapper based selection. At long last, the selected feature set was characterized utilizing support vector machine (SVM). Finally, to appraise the proposed strategy' accuracy LOOCV was utilized. The obtained average accuracies on CASIA

Ver.4-lamp and Ver.1 were 99.96 % and 99.97 % individually.

Segmentation methods on iris recognition

Segmentation is vital with merely precisely segmented images appropriate for proceeding to the iris recognition's later phase. Surjeet Singh and Kulbir Singh discussed about various segmentation techniques' performance to progress the overall iris recognition accuracy [18]. Table 2 discussed about the various segmentation and their drawbacks.

Machine Learning approach on iris recognition

Naiara Aginako *et.al* [22] introduced a means meant for iris difference computation predicated on Computer Vision accompanied by Machine Learning. The fundamental novelty of the displayed work stays in the computation of the dissimilarity value of two iris images as the separation between the previously mentioned posteriori probabilities. Experimental results, centered upon the testing dataset given by the MICHE II Challenge coordinators, demonstrated the appropriate conduct of the conveyed process aimed at the iris recognition task. Most excellent outcome demonstrated an accuracy score over 90% notwithstanding aimed at iris images of new people.

Francesco Marra *et.al* [23] offered an algorithm grounded upon convolutional neural networks aimed at iris sensor display identification. A conceivable solution comprises in first differentiating the sensor model and afterwards mapping the features extracted as of the image from one sensor to the other. They established that the presented solution beats the cream of the crop approaches utilized for the model identification task. At that point, they tried the biometric recognition framework's performance and demonstrated that enhancing the sensor model identification stage can profit the iris sensor interoperability.

Table 2: Comparative analysis of various segmentation algorithms on iris recognition

Author's name	**Algorithm used**	**Advantages**	**Disadvantages**
Meriem Yahiaoui *et.al* [19]	Unsupervised iris segmentation using Markov Chains	Limiting the time for processing devoid of deterioration of the result performance.	Focused only on NIR eye images.
Abduljalil Radman *et.al* [20]	HOG-SVM and Grow Cut.	Reduces false segmentation. Proposed algorithm doesn't need parameter modification for the different database.	The Complex algorithm owing to some ante and post processing techniques.
Maria Frucci *et.al* [21]	Watershed Segmentation	Iris recognition performance stands improved.	Less Accuracy for pupil boundary identification. High Processing Time

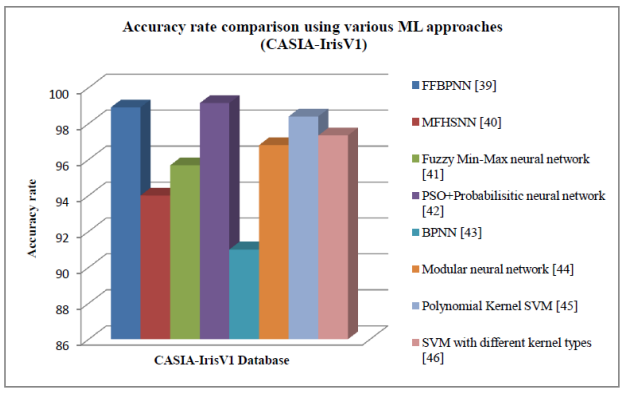
Table 3: Comparative analysis of machine learning approach on iris recognition

Author name	**Dataset**	**Features**	**Recognition accuracy %**	**Technique used**
Abiyev and Altunkaya [24]	2008 CASIA-IrisV1	Intensity image	99.25	NN feature gradient centered learning algorithm with adaptive learning rate
Mohtashim Baqar *et.al,* 2011 [25]	MMU Iris Database	Dual boundary contour vector	99	Dual boundary detection via robust variable learning rate Multilayer FFNN.
Chen and Chu,2005 [26]	CASIA	Sobel and vertical projections	EER=3,32%	Wavelet Neural Network and PNN
Fernando Gaxiola *et.al,* 2011 [27]	CASIA-IrisV1	Masek and Kovasi	97.98	Modular Neural Network with type-2 fuzzy integration on submodule level and also Gating Network integration at the module level
Patricia Melin *et.al*, 2012[28]	CASIA-IrisV3	Wavelet transform	99.76	ANN + Fuzzy Integrator + Genetic Algorithm
Muhammad Moinuddin et.al, 2004[29]	Daugman's iris dataset	1D iris contour	97	Multilayer Feedforward neural network (MFNN) and Radial basics function neural network (RBFNN)
Lie Nie et.al, 2014 [30]	UBIPr	-	50.1	Unsupervised Convolutional Restricted Boltzmann Machine Feature Learning

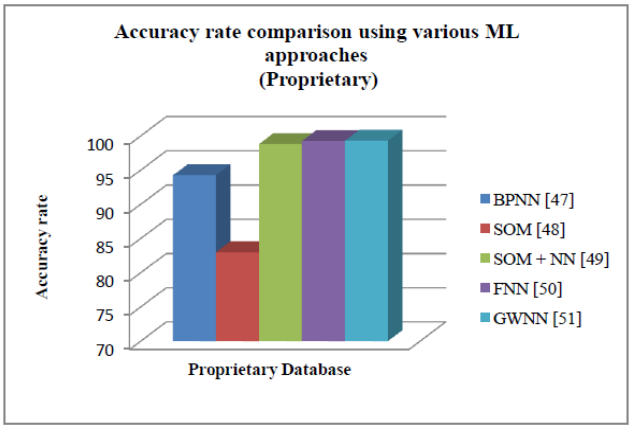
Author name	Dataset	Features	Recognition accuracy %	Technique used
Jaishanker K. Pillai et.al, 2013[31]	Notre Dame (ND)	Daugman's iris code	87.82	Kernel-learning framework for cross-sensor adaptation
Roy Kaushik and Prabir Bhattacharya 2007 [32]	ICE WVU	2D Gabor wavelet	97.7 95.6	Multi-objectives Genetic Algorithm (MOGA) and asymmetrical SVM
Saminathan *et.al*, 2015 [33]	CASIAIrisV3-Interval	Intensity image	98.5	Least square method of quadratic kernel SVM
Sarhan, 2009 [34]	CASIA-IrisV2	2D -DCT	96	Artificial Neural Networks (ANN)
Sibai *et.al,* 2011[35]	CHEK	RGB image	93.3	Feed-forward Neural Network (FNN)
Vivek Srivastava *et.al,* 2014 [36]	CASIA	Evolutionary fuzzy clustering	98.12	Evolutionary fuzzy clustering and functional modular neural network
Sundaram and Dhara, 2011[37]	UBIRIS.V1	Haralick features	97	Haralick features + Probabilistic Neural network (PNN)
Zhang et.al, [38]	N/A	N/A	99.33	Adaptive PSO

Discussion

Table 3 sum up all the machine learning process that have been employed aimed at iris recognition, giving a quick contrast of the chief features together with performance concerning the specific datasets utilized. Different sorts of neural networks investigated as feature classifiers like, BPNN, RBFNN, ANN etc. Each technique possesses its own benefit. Also, neural networks cover high training time consequently researchers test technique to hybridize them with the GA together with PSO to lessen their complexity. SVM allows the utilization of various kernel functions to avoid the explicit mapping of feature vectors onto a higher dimensional space. Deep learning stand as the new frontier of Machine Learning and this approach has the potential to solve all the above problems. It will be interesting in the forthcoming years to contrast its performance and computational demand with that of more customary algorithms. [24] [25] have achieved high recognition rates using NN while [38] have achieved high rates using PSO techniques. Figure 2 reveals the comparative analysis' graphical representation on numerous machine learning methods. For the reason of comparison, CASIA-IrisV1 and Proprietary databases have used in figure 3 respectively. Table 4 exhibits the accuracy comparison regarding EER, CRR and FRR.



(a)



(b)

Figure 2: Graphical comparative analysis on various machine learning approach (a) CASIA-Iris V1 database (b) Proprietary database

Table 4: Accuracy comparisons on CASIA-Iris V3-Interval database

Author name	FRR(%) @FAR=0.001%	EER (%)	CRR (%)
Kong and Zhang [52]	2.57	0.59	99.14
He *et.al* [53]	1.90	0.46	99.28
Jang *et.al* [54]	1.91	0.53	99.34
Min and Park [55]	2.37	0.53	99.34
HamedGhodrati*et.al* [56]	3.16	0.93	98.42
HamedGhodrati*et.al* [57]	1.51	0.40	99.34
Ma *et.al.* [58]	Nil	0.39	99.59

CONCLUSION

Iris recognition stands as a vital topic in biometrics, holding marvelous potential intended for a vast array of real-life applications. This paper as well presents a literature survey on the various segmentation techniques associated in iris recognition, the Iris recognition's importance is also introduced and as well the various sorts of IRIS recognition process besides their limitations are discussed briefly. This literature work enlightens the various existing methods of iris segmentation proposed by various diverse researchers occasionally which assists the researchers in forthcoming effort in this particular area. For the upcoming work, we suggested working on addressing the current research problem that was discussed above along with it we would like to explore Machine Learning and segmentation approaches that have the potential to cause the iris recognition easier. It will be motivating in the forthcoming years to compare the performance and computational demand with that of more customary algorithms

REFERENCES

[1] Gil Santos and Edmundo Hoyle, "A fusion approach to unconstrained iris recognition", Pattern Recognition Letters, Vol. 33, No. 8, pp. 984-990, 2012.

[2] Tieniu Tan, Xiaobo Zhang, Zhenan Sun and Hui Zhang, "Noisy iris image matching by using multiple cues", Pattern Recognition Letters Vol. 33, No. 8, pp. 970-977, 2012.

[3] Swathi S. Dhage, Sushma Shridhar Hegde, K. Manikantan and S. Ramachandran, "DWT-based feature extraction and radon transform based contrast enhancement for improved iris recognition", Procedia Computer Science Vol. 45, pp. 256-265, 2015.

[4] Kamal Hajari, Ujwalla Gawande, and Yogesh Golhar, "Neural Network Approach to Iris Recognition in Noisy Environment", Procedia Computer Science, Vol. 78, pp. 675-682, 2016.

[5] S. Poornima, C. Rajavelu, and S. Subramanian, "Comparison and a neural network approach for iris localization", Procedia Computer Science Vol. 2, pp. 127-132, 2010.

[6] Nianfeng Liu, Jing Liu, Zhenan Sun and Tieniu Tan, "A Code-level Approach to Heterogeneous Iris Recognition", IEEE Transactions on Information Forensics and Security, Vol. 12, No. 10, pp. 2373 – 2386, 2017.

[7] Sheng-Hsun Hsieh, Yung-Hui Li, Chung-Hao Tien, and Chin-Chen Chang, "Extending the capture volume of an iris recognition system using wavefront coding and super-resolution", IEEE transactions on cybernetics Vol. 46, No. 12, pp. 3342-3350, 2016.

[8] Chun-Wei Tan and Ajay Kumar, "Efficient and accurate at-a-distance iris recognition using geometric key-based iris encoding", IEEE Transactions on Information Forensics and Security Vol. 9, No. 9, pp. 1518-1526, 2014.

[9] Chun-Wei Tan and Ajay Kumar, "Accurate iris recognition at a distance using stabilized iris encoding and zernike moments phase features", IEEE Transactions on Image Processing Vol. 23, No. 9, pp. 3962-3974, 2014.

[10] Jianxu Chen, Feng Shen, Danny Ziyi Chen and Patrick J. Flynn, "Iris recognition based on human-interpretable features", IEEE Transactions on Information Forensics and Security Vol. 11, No. 7, pp. 1476-1485, 2016.

[11] Zhiyong Peng, Hongchen Wang, Jun Wu, and Jun Li, "An improved Daugman method for iris recognition", Wuhan University Journal of Natural Sciences Vol. 20, No. 3, pp. 229-234, 2015.

[12] Imran Naseem, Affan Aleem, Roberto Togneri and Mohammed Bennamoun, "Iris recognition using class-specific dictionaries", Computers & Electrical Engineering Vol. 62, pp.178-193, 2016.

[13] Farmanullah Jan, Imran Usman, and Shahrukh Agha, "Reliable iris localization using Hough transform, histogram-bisection, and eccentricity", Journal of Signal Processing Systems Vol.93, No.1,pp-230-241

[14] Zhonghua Lin, Hongfei Yu, "The Pupil Location Based on the OTSU Method and Hough Transform", Procedia Environmental Sciences ,No.8 pp.352 – 356, 2011.

[15] Yuniol Alvarez-Betancourt, and Miguel Garcia-Silvente, "A keypoints-based feature extraction method for iris recognition under variable image quality conditions", Knowledge-Based Systems, Vol. 92, pp. 169-182, 2016.

[16] Soubhagya Sankar Barpanda, Banshidhar Majhi, PankajKumarSa, "Region based feature extraction from non-cooperative iris images using triplet half-band filterbank", Optics & Laser Technology, Vol. 72, pp. 6–14, 2015

[17] Sirvan Khalighi, Fatemeh Pak, Parisa Tirdad, and Urbano Nunes, "Iris recognition using robust localization and nonsubsampled contourlet based features", Journal of Signal Processing Systems Vol. 81, No. 1, pp. 111-128, 2015.

[18] Surjeet Singh and Kulbir Singh, "Segmentation techniques for Iris recognition system", International Journal of Scientific & Engineering Research, Vol. 2, No. 4, pp. 1-8, 2011.

[19] Meriem Yahiaoui, Emmanuel Monfrini and Bernadette Dorizzi, "Markov Chains for unsupervised segmentation of degraded NIR iris images for person recognition, Vol. 82, No. 2, pp.116-123,2016.

[20]Abduljalil Radman, Nasharuddin Zainal, and Shahrel Azmin Suandi, "Automated segmentation of iris images acquired in an unconstrained environment using HOG-SVM and GrowCut", Digital Signal Processing, Vol. 64, pp. 60-70, 2017.

[21]Maria Frucci, Michele Nappi, Daniel Riccio, and Gabriella Sanniti di Baja, "WIRE: Watershed based iris recognition", Pattern RecognitionVolume 52, Pp.148-159, 2016

[22] Naiara Aginako, Goretti Echegaray, J.M. Martínez-Otzeta, Igor Rodríguez , Elena Lazkano , Basilio Sierra , " Iris matching by means of Machine Learning paradigms: A new approach to dissimilarity computation", Pattern Recognition Letters,pp.1-5 2017,

[23] Francesco Marra, Giovanni Poggi, Carlo Sansone and Luisa Verdoliva, "A deep learning approach for iris sensor model identification", Pattern Recognition Letters pp.1–8,2017.

[24] Abiyev R.H. and Altunkaya, K. "Personal iris recognition using neural network", International Journal of Security and its Applications Vol. 2, No. 2, pp. 41-50, 2008

[25] Mohtashim Baqar, Sohaib Azhar, Zeeshan Iqbal, Irfan Shakeel, Laeeq Ahmed and Muhammad Moinuddin, "Efficient iris recognition system based on dual boundary detection using robust variable learning rate Multilayer Feed Forward neural network", In Information Assurance and Security (IAS), 2011 7th International Conference on, pp. 326-330, IEEE, 2011.

[26] Chen C.H. and Chu, C.T "Low complexity iris recognition based on wavelet probabilistic neural networks", In Neural Networks, 2005, IJCNN'05, Proceedings, 2005 IEEE International Joint Conference on, Vol. 3, pp. 1930-1935, IEEE, 2005.

[27] Fernando Gaxiola, Patricia Melin, Fevrier Valdez and Oscar Castillo, "Modular neural networks with type-2 fuzzy integration for pattern recognition of iris biometric measure", In Mexican International Conference on Artificial Intelligence, pp. 363-373, Springer, Berlin, Heidelberg, 2011.

[28] Patricia Melin, Victor Herrera, Danniela Romero, Fevrier Valdez, and Oscar Castillo, "Genetic optimization of neural networks for person recognition based on the Iris", TELKOMNIKA (Telecommunication Computing Electronics and Control) Vol. 10, No. 2, pp. 309-320, 2012.

[29] Muhammad Moinuddin, Mohamed Deriche and SYED SAAD AZHAR Ali, "A new iris recognition method based on neural networks", WSEAS Transactions on information science and applications, Vol. 1, No. 6 2004.

[30] Lei Nie, Ajay Kumar and Song Zhan, "Periocular recognition using unsupervised convolutional RBM feature learning", In Pattern Recognition (ICPR), 2014 22nd International Conference on, pp. 399-404, IEEE, 2014.

[31] Jaishanker K. Pillai, Maria Puertas, and Rama Chellappa, "Cross-sensor iris recognition through kernel learning", IEEE transactions on pattern analysis and machine intelligence Vol. 36, No. 1, pp. 73-85, 2014.

[32] Roy Kaushik and Prabir Bhattacharya, "Application of multi-objective genetic algorithm and asymmetrical support vector machine to improve the reliability of an iris recognition system", In Systems, Man and Cybernetics, 2007, ISIC, IEEE International Conference on, pp. 1952-1957, IEEE, 2007.

[33] K. Saminathan, T. Chakravarthy and M. Chithra Devi, "Iris recognition based on kernels of support vector machine", ICTACT J. Soft Comput, Vol. 5, No. 5, pp. 889-895, 2015.

[34] Sarhan, A.M. "Iris Recognition Using Discrete Cosine Transform and Artificial Neural Network", Journal of Computer Science Vol. 5, No. 5, pp. 9-373, 2009.

[35] Fadi N. Sibai, Hafsa I. Hosani, Raja M. Naqbi, Salima Dhanhani, and Shaikha Shehhi, "Iris recognition using artificial neural networks", Expert Systems with Applications Vol. 38, No. 5, pp. 5940-5946, 2011.

[36] Vivek Srivastava, Bipin Kumar Tripathi and Vinay Kumar Pathak, "Biometric recognition by hybridization of evolutionary fuzzy clustering with functional neural networks", Journal of Ambient intelligence and humanized computing Vol. 5, No. 4, pp. 525-537, 2014.

[37] Sundaram R.M. and Dhara, B.C. "Neural network based Iris recognition system using Haralick features", In Electronics Computer Technology (ICECT), 2011 3rd International Conference on, vol. 3, pp. 19-23, IEEE, 2011

[38] Zhang, J.R. Jun Zhang, Tat-Ming Lok, and Michael R. Lyu, "A hybrid particle swarm optimization–back-propagation algorithm for feedforward neural network training", Applied mathematics and computation Vol. 185, No. 2, pp. 1026-1037, 2007.

[39] Omaima N. AL-Allaf, Ahmad, Shahlla A. AbdAlKader and Abdelfatah Aref Tamimi, "Pattern recognition neural network for improving the performance of Iris recognition system", Journal of Scientific and Engineering Research Vol. 4, No. 6, pp. 661-667, 2013.

[40] S.S. Chowhan, U. V. Kulkarni, and G. N. Shinde, "Iris recognition using modified fuzzy hypersphere neural network with different distance measures", International Journal of Advanced Computer Science and Applications Vol. 2, No. 6, pp. 122–129, 2011.

[41] S. S. Chowhan and G. N. Shinde, "Iris recognition using fuzzy min-max neural network", International Journal of Computer and Electrical Engineering Vol. 3, No. 5, 743-749, 2011.

[42] Chia Te Chu and Ching-Han Chen, "High performance iris recognition based on LDA and LPCC", In Tools with Artificial Intelligence, 2005, ICTAI 05, 17th IEEE International Conference on, pp. 5-pp. IEEE, 2005.

[43] Fasca Gilgy Mary, P. Sunitha Kency Paul, J. Dheeba, "Human Identification Using Periocular Biometrics", International Journal of Science, Engineering and Technology Research (IJSETR) Vol. 2, No. 5, 2013.

[44] Fernando Gaxiola, Patricia Melin and Miguel López, "Modular neural networks for person recognition using segmentation and the iris biometric measurement with image pre-processing", In Neural Networks (IJCNN), The 2010 International Joint Conference on, pp. 1-7, IEEE, 2010.

[45] Gu Hongying, "Research on Iris Recognition Based on Self-Similarity", JOURNAL OF COMPUTER AIDED DESIGN AND COMPUTER GRAPHICS Vol. 16, No. 7, pp. 973-977, 2004.

[46] Kaushik Roy and Prabir Bhattacharya, "Iris recognition with support vector machines", In International Conference on Biometrics, pp. 486-492, Springer, Berlin, Heidelberg, 2006.

[47] Usham Dias, Vinita Frietas, P. S. Sandeep and Amanda Fernandes, "A Neural Network Based Iris Recognition System for Personal Identification", ICTACT Journal On Soft Computing, Vol. 1, No. 2, pp. 78-84, 2010.

[48] Lye Wil Liam, Ali Chekima, Liau Chung Fan, and Jamal Ahmad Dargham, "Iris recognition using self-organizing neural network", In Research and Development, 2002, SCOReD 2002, Student Conference on, pp. 169-172, IEEE, 2002.

[49] Bo Lu, Jing-jing Wu and Yu Wang, "A iris recognition algorithm based on ICA and SOM neural network", In Image and Signal Processing (CISP), 2010 3rd International Congress on, Vol. 5, pp. 2445-2448, IEEE, 2010.

[50] K. Aishwarya Raghavi, M. Vishnu Priya, G. Prowino Madonna Paiva, and Saranya Mohan, "Human iris recognition using fuzzy neural concepts", In The International Conference on Bioscience, Biochemistry and Bioinformatics (IPCBEE), Vol. 5, pp. 256-260. 2011.

[51] Zhou, Zhiping, Huijun Wu, and Qianxing Lv, "A new iris recognition method based on Gabor wavelet neural network", In Intelligent Information Hiding and Multimedia Signal Processing, 2008, IIHMSP'08 International Conference on, pp. 1101-1104, IEEE, 2008.

[52] Kong W.K., Zhang, D.: Accurate iris segmentation based on novel reflection and eyelash detection model. In: International Symposium on Intelligent Multimedia, Video & Speech Processing, 2001

[53].He, Z., Tan, T., Sun, Z., Qiu, X. "Robust eyelid, eyelash and shadow localization for iris recognition", In: Proceedings of the International Conference on Image Processing, pp. 265–268,2008

[54]. Jang, Y.K., Kang, B.J., Park, K.R. "A study on eyelid localization considering image focus for iris recognition", Pattern Recogn Lett. Vol. 29, pp. 1698–1704, 2008

[55]Min, T.H., Park, R.H. "Eyelid and eyelash detection method in the normalized iris image using the parabolic Hough model and Otsu'sthresholding method", Pattern Recogn, Lett Vol. 30, pp. 1138–1143, 2009.

[56] Ghodrati, H., Dehghani, M.J., Danyali, H. "Iris feature extraction using optimized Gabor wavelet based on multi objective genetic algorithm", In: International Symposium on Innovations in Intelligent Systems and Applications (INISTA) 2011.

[57] Ghodrati, H. Dehghani, M.J. and Danyali, H. "A new accurate noise-removing approach for non-cooperative iris recognition", Signal, Image and Video Processing Vol. 8, No. 1, pp. 1-10, 2014

[58] L. Ma, T. Tan, Y. Wang, and D.Zhang, "Efficient iris recognition by characterizing key local variations", IEEE Transactions on Image Processing .Vol. 13, pp.739–750, 2004.