FEATURE EXTRACTION METHODS FOR IRIS RECOGNITION SYSTEM: A SURVEY

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ABSTRACT

Protection has become one of the biggest fields of study for several years, however the demand for this is growing exponentially mostly with rise in sensitive data. The quality of the research can differ slightly from any workstation to cloud, and though protection must be incredibly important all over. Throughout the past two decades, sufficient focus has been given to substantiation along with validation in the technology model. Identifying a legal person is increasingly become the difficult activity with the progression of time. Some attempts are introduced in that same respect, in particular by utilizing human movements such as fingerprints, facial recognition, palm scanning, retinal identification, DNA checking, breathing, speech checker, and so on. A number of methods for effective iris detection have indeed been suggested and researched. A general overview of current and state-of-the-art approaches to iris recognition is presented in this paper. In addition, significant advances in techniques, algorithms, qualified classifiers, datasets and methodologies for the extraction of features are also discussed.

KEYWORDS

Bio-metric traits, iris patterns, feature extraction, SVM, wavelet transform, iris security.

1. INTRODUCTION

The most significant security issue today is verification; if researchers can enhance this area, it implies they are reducing security threats. Various secure techniques were used, including security, but today a biometric technology known as iris recognition provides security in terms of verification. Humans live in a safe environment owing to the unique iris pattern, but they also have evil genius brains that can break the protection. As a result, academics are working to develop more secure iris recognition technologies for a more safe society [1].

There are three focused categories of verification, such as starting from password, but this was a very weak way to secure any system or object from hackers. The next method was card or token, but that was also a very low-level security method. Anyone could present a card or token on their own. The last step for security is biometric, and this method provides real security to verification. According to the biometric method, no one can emulate or steal natural human patterns [2 - 3].

Verification of a person based on physiological and behavioral aspects. Face, finger prints, palm and hand geometry, DNA, retinal and iris trends are some of the most commonly observed physical aspects in a person, while signatures, tone of voice, walking style, and keystrokes are

DOI: 10.5121/ijcsit.2022.14107

some of the most frequently observed behavioral aspects. From all of these above patterns, the iris is the only method that is used for security verification [4].

Now a question arises about the word biometric. What is a biometric? It consists of two words. Bios means life and metrikos means measurement, so when researchers use these two words together, it becomes biometric. Therefore, a biometric system capable of identifying a person's traits stands upon a feature vector [7].

Biometric systems consist of four major parts, such as the sensor unit, feature extraction element, matching pattern, and decision response. Consequently, when a biometric system is applied to a human trait, there are four basic conditions that a human must have, like entirety, uniqueness, immovability, and collectability. There is a comparison between some biometric systems according to their factors in terms of High (H), Medium (M) and Low (L) in table 1 [8].

TABLE 1. Comparison between biometric systems with their factors

Biometric traits	**Entirety**	**Uniqueness**	**Immovability**	**Collectability**
Face recognition	H	L	M	H
Walking style	M	L	L	H
Keystroke dynamics	L	L	L	M
Odor	H	H	H	L
Ear	M	M	H	M
Hand geometry	M	M	M	H
Finger print	M	H	H	M
Retina	H	H	M	L
Palm print	M	H	H	M
Tone of voice	M	L	L	M
DNA	H	H	H	L
Signature	L	L	L	H
Iris	H	H	H	M

In the modern age of secure applications, there are some traditional issues which have a great impact on biometric systems, as described in Table 2 with their impact factor also in terms of High, Medium, and Low [8].

TABLE 2. Biometric system traditional factors with their impact

Biometric traits	**Performance**	**Acceptability**	**Circumvention**
Face recognition	L	H	H
Walking style	L	H	M
Keystroke dynamics	L	M	M
Odor	L	M	L
Ear	M	H	M
Hand geometry	M	M	M
Finger print	H	M	M
Retina	H	L	L
Palm print	H	M	M
Tone of voice	L	H	H
DNA	H	L	L
Signature	L	H	H
Iris	H	L	L

As a result, iris recognition is a fully systematic biometric system in which issues are resolved using various mathematical methods, and these methods are directly applied to individual eye images that are considered distinctive [9 - 11]. There are many possible approaches which can be used for iris recognition, but formally, researchers divided these approaches into three known categories, such as supervised, unsupervised, and semi-supervised approaches. In supervised approaches, trained data is available for testing by using different classifiers, while according to unsupervised learning approaches, using unlabelled data, the working style of this approach is slightly different from the supervised approach. If the data pool has a smaller amount of trained data and a huge amount of untrained data, then researchers recommend the semi-supervised approaches.

The first section contains an introduction to the study that is relevant to the research. The second section is about the related research work, and the third portion describes the methodology of the research. The results and discussion section is under the umbrella of the fourth portion of the study, and at the end, the conclusion is included as a final discussion.

2. LITERATURE REVIEW

There are some main contributed articles that are considered related works. Due to certain resolving issues, iris recognition systems are considered the main stream for security verification of individuals. Nanik Suciati [12] presents an automatic recognition system for a person's identification based on eye image. Canny Edge Detection (CED) with Hough Transform techniques used for iris detection, followed by features selected by Wavelet Transform at the last Support Vector Machine (SVM) classifier trained for feature representation, provides 93.5% of the results. In [13], researchers worked on optimizing attribute mining according to the wavelet task, while for the similarity method, they used multi-class SVM with an ant colony algorithm and gave better outcomes in terms of performance.

Tejas's [14] research concept is based on energy compression, and three different Self Mutated Hybrid Wavelet Transforms (SMHWT) methods are used to generate feature vectors. Characteristics basic purpose of this research is to reduce vector size, with the help of partial energy and the Genuine Acceptance Rate (GAR) metric. Cosine-Haar provides the best GAR accuracy rate. Researchers [15] provide scattering and textural feature sets for the reduction of dimensionality according to the Principle Component Analysis (PCA) method and the minimum distance classifier algorithm, which are also used for matching and get a 99.2% accuracy rate. Kiran [16] gives the idea of vigorous segmentation of detectable iris examples while estimating the radius of the iris with a new deep sparse filtering algorithm for unsupervised learning. The proposed method shows 85% accuracy in correct results on both the existing dataset and the newly generated dataset VSSIRIS. Authors [17] give the idea of attribute mining the name "vigorous keypoints method". In this method, they merge three detectors as regards SIFT features for corresponding score points. The unions take care of the calculation of weights with summation regulations and provide competitive performance as compared to baseline methods.

Lydia Elizabeth [18] presents her work in 2014 on a grid-based algorithm for feature extraction that combines Singular Value Detection (SVD) and Discrete Wavelet Transform (DWT). Therefore, this hybrid process offers a powerful, protected, and imperceptible watermarking method with a minimum fault acceptance rate in good behavior. Imen Tajouri [19] improves on Rai's algorithm by combining HAAR wavelet, 2D Log Gabor, and a monogenic filter for feature extraction. This shows the 94.45% empirical results of the proposed method as compared to the Daubechies wavelet and Histogram of Oriented Gradient (HOG). A deep learning approach named convolutional neural network is integrated with a fusion method for iris recognition [43]. The feed forward mechanism proposed along a clustering method k-mean for the iris feature extraction. The approach reduces the calculated time and size of source link as well as improves the iris recognition [44]. An intelligent method presented for iris feature extraction and matching activity in which the two hybrid methods used for this activity. Besides this, machine learning algorithm is also include in the research as apart of matching approach which gives more efficient results [45].

To address the low false rejection issue in feature extraction, the proposed Combined Directional Wavelet Filter Bank (CDWFB) [20] algorithm combines the Directional Wavelet Filter Bank (DWFB) and the Rotated Directional Wavelet Filter Bank (RDWFB). This approach extracts the texture of the iris in 12 directions and provides excellent results as compared to more exciting approaches. Researchers proposed [21] a hybrid technique design based on sparse demonstration, including three classifiers for classes' short list and further work on classes after that work combining these classifiers with genetic algorithms to provide the best results. Table 3 shows the considered articles as reviewed for related work and explains the main contributions of the researchers.

TABLE 3. Biography of under consideration articles

Author name	**Article name**	**Search engine**
Amol D. Rahulkar and Raghunath S. Holambe [14]	Partial iris feature extraction and recognition based on a new combined directional and rotated directional wavelet filter banks	Elsevier
Vijay Prakash Sharma, et al [7]	Improved Iris Recognition System using Wavelet Transform and Ant Colony Optimization	IEEE
Lydia Elizabeth. B, et al [12]	A grid based iris biometric watermarking using wavelet transform	IEEE
Shervin Minaee, et al [9]	Iris recognition using scattering transform and textural features	IEEE
Kiran B. Raja, et al [10]	Smartphone based visible iris recognition using deep sparse filtering	Elsevier
Nanik Suciati, et al [6]	Feature Extraction Using Statistical Moments of Wavelet Transform for Iris Recognition	IEEE
Tejas H. Jadhav and Jaya H. Dewan [8]	Iris Recognition using Self Mutated Hybrid Wavelet Transform using Cosine, Haar, Hartley and Slant Transforms with Partial Energies of Transformed Iris Images	IJCA
Yuniol Alvarez-Betancourt and Miguel Garcia-Silvente [11]	A keypoints-based feature extraction method for iris recognition under variable image quality conditions	Elsevier
Imen Tajouri, et al [13]	An Efficient Iris Texture Analysis Based On HAAR Wavelet 2D Log Gabor and Monogenic Filter	IEEE
Ashok K Bhateja, et al [15]	Iris recognition based on sparse representation and k-nearest subspace with genetic algorithm	Elsevier

3. METHODOLOGY

Iris recognition is performed by the different biometric systems. Due to certain specifications, the evaluation process of iris recognition systems is divided into four major modules, which are mentioned in Figure 1.

The very first step of iris recognition is acquiring the iris images from different types of objects through electronic devices like cameras or sensors etc. Each image has elucidation, location area among corporeal incarcerate structure, and other factors such as occlusion, illumination, and pixel extent play an important role in image eminence [22].

The second step is early stage processing, in which we check the iris liveness and edge, pupil, eyelid, normalization, subtraction of iris etc. Through iris liveness recognition, the security system can check if the focal object is alive because there is an option in which biometric aspects are employed illegitimately. Localization of the iris and pupil is another important preprocessing step that was developed by Zhaofeng [5 - 6].

As a result, the parabolic arcs perform conformant of the eyelids and then plot this extorted iris area according to the normalization. All forces composition [23] comes from the commencement of the summation of points which examine the iris and pupil centre within the radius. Some functions attained iris boundaries through applied form in [24]. The basic law of iris localization is based on incline strength along consistency divergence [25].

Classification is performed through extracted aspects of iris images in the third step, where some aspects have important variants such as 90° axis, range and dimensions of pupil, strength, direction according to ellipsoid shape, and all the features snatched from the iris images which are useful for security verification are organized in this step. The last step used processed iris images along with stored images for the matching process [26]. Due to inter-class and intra-class variables, classification issues can be resolved. Table 4 describes some important methods of iris recognition according to their influence on results in the form of performance, where Equal Error Rate (EER), False Rejection Rate (FRR) and False Acceptance Rate (FAR) are used as performance measures.

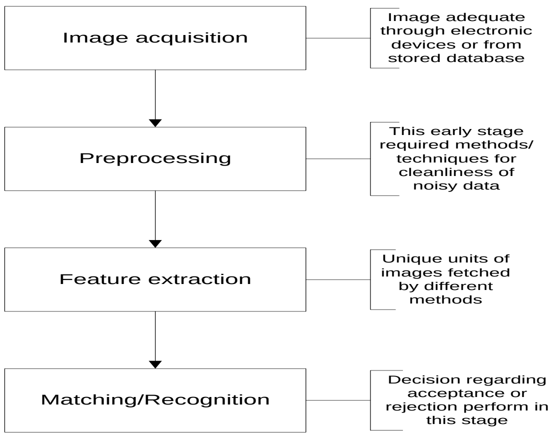

FIGURE 1. Iris recognition system

TABLE 4. Iris patterns based methods with their performance and average time

Methods	Reference	Stored patterns in DB	Performance	Average time taken (seconds)
Phase based method	Daugman [27,28]	4258 images	EER: 0.08%	0.71, 0.68
	Martin Roche [29]	300 images	FRR: 8%	0.89
	Masek [30]	624 images	FAR: 0.005% and FRR: 0.238%	0.92
	Xiaomei Liu [31]	12000 images (ICE)	Recognition rate: 96.61%	0.78
	Karen Hollingsworth [32]	(i) 1226 images from 24 subjects (ICE) (ii) 1061 videos from 296 eyes (iii) ICE database (iv) 1263 images from 18 subjects (ICE)	(i)HD=7.48 (ii)EER=3.88x10-3, FRR =7.61x10-6, FAR=0.001 (iii) HD=0.15 (iv)FRR=0.271, FAR = 0.001, EER=0.068 for large pupil subset	Null
Texture analysis based method	Wildes [33, 34, 35]	60 images	EER: 1.76%	0.62, 0.69, 0.78
	Emine Krichen [36]	700 images	Improvement in FAR: 2% and FRR: 11.5%	0.88
Zero crossing representation method	Boles [37]	Real images	EER: 8.13%	0.69
Intensity variations based method	Li Ma [26, 38]	2245 images (CASIA)	Correct Recognition Rate: 94.33%.	0.77, Null
	Jong Gook Ko [39]	(i) 820 images from 82 individuals (ii) 756 images (CASIA)	Recognition rate: 98.21%	0.66
	N. Tajbakhsh [40]	1877 images (UBIRIS)	ERR: 0.66%, FRR: 4.10% and FAR: 0.01%	0.71
Independent Component Analysis (ICA) based method	Ya Ping Haung [41]	Real images	Blurred iris: 81.3%, Variant illumination: 93.8% and Noise interference: 62.5%	0.65
Continuous Dynamic Programming based method	Radhika [42]	(i)1205 images (UBIRIS) (ii)1200 images (CASIAv2)	Acceptance Rate: 98% Rejection Rate 97%	Null

4. RESULTS AND DISCUSSION

Table 5 shows the performance of the under consideration articles by SVM, PCA, different algorithms and classifiers with their accuracy. Normally, SVM used with the combination of some type of filters and statistical methods such as SVM with wavelet transform and colony gives 93.5% and 98% results respectively. On the other hand, PCA was used with distance classifiers and provided better results, like 99.2% accuracy. The Deep Sparse Algorithm is a filtering algorithm used for the VSSIRIS dataset and has shown 85% accuracy in empirical tests. The CED algorithm is based on grid watermarking. This is used for the global iris recognition dataset and minimizes the fault acceptance and error rate by approximately 77%. The Genetic Algorithm (GA) is associated with three classifiers and helps to reduce the execution time. There are many algorithms used for feature extraction, like enhancement in Rai's algorithm integrated with filters, while on the basis of keypoints extraction, there are marginal improvements among three detectors such as Harris, Hessian, and Fast Laplace. For the reduction of feature vector size, researchers used the self-mutated hybrid wavelet transform method and adequate 14% improvement in the results.

Figure 2 shows the testing results of articles in diverse domains that contain the time and frequency developed through the measurements of performance. Consequently, figure 3 describes the measurement results in terms of performance according to their relevant datasets, and several feature extraction methods and algorithms were applied to these datasets and improved the angle of performance and accuracy. In figure 4, we select the articles that have diversity in methods such as phase-based methods, texture analysis methods, zero crossing representation based methods, intensity variations based methods, independent component analysis based methods, and continuous dynamic programming based methods along with their performance according to the FAR and FRR with recognition and error rate.

TABLE 5. Summary of performance under reviewed articles with different applied methods

Task	**Approach**	**Dataset**	**Result**	**Primary objectives**	**Limitations/future work**
Iris recognition system [12]	SVM with Wavelet transform	CASIA eye image	93.5%	Detection of iris area with suitable selected features and then representation of these features are the focus objectives of this research.	Improvement in results regarding accuracy and execution time
Selection of optimized feature [13]	SVM with ant colony	CASIA eye image	99% for FAR and 98% for FFR	Selection and optimization operations perform with the help of multi class SVM and ant colony process.	Reduction of computational time
Feature vector size reduction [14]	Self mutated hybrid wavelet transforms	Palacky University Iris DB	14% improvement	The SMHWT reduce the feature vector size and Cosine-Haar used partial energy with best improvement in GAR function.	Color spaces use for better performance
Dimensionality reduction of feature vector [15]	Principal component analysis (PCA) with minimum distance classifier	Iris DB collected by IIT Delhi	99.2%	Reduce dimensions of two proposed feature sets according to PCA and algorithm used for best accuracy.	Proposed set of features test on other datasets and biometric detection issues
Robust segmentation for iris recogniti	deep sparse filtering algorithm with VSSIRIS	BIPLab DB and VSSIRIS newly created	85% accuracy	A deep sparse filtering method used for robust segmentation of observable range iris recognition provides high outcomes on	Supervised learning improve the accuracy

on [16]	dataset	DB		newly created dataset.	
Feature extraction [17]	Keypoints-based feature extraction method	CASIA-IrisV4-Interval, MMU2, and UBIRIS 1DB	68%	Keypoints feature extraction combine three detectors like Harris, Hessian and Fast Laplace as a SIFT features for matching score level and calculate the weights for attain better performance.	Implementation of real time application
Feature extraction [18]	Grid based approach used Canny Edge Detection (CED) algorithm	Global iris recognition dataset	77%	Grid based watermarking algorithm used with a hybrid SVD and DWT for minimizing fault acceptance and error rate.	Watermarking algorithm accuracy
Feature extraction [19]	Rai's algorithm for attribute extraction	CASIA V1.0 and CASIA V3.0	94.45%	Enhance the Rai's algorithm with combination of monogenic filter and 2D Log Gabor filter	Gabor Ordinal Measures GOM) test for feature extraction
Feature extraction [20]	Combined Directional Wavelet Filter Bank (CDWFB) proposed approach	UBIRIS and MMU1 DBs	99% accuracy for UBIRIS and 98% accuracy for MMU1	CDWFB a new approach for feature extraction consists of two different filter banks and provide better performance in terms of accuracy.	Improve the performance on real time applications
Reduction of time [21]	Three classifiers with genetic algorithm	CASIA and IITD DBs	99.43% on CASIA and 99.20% on IITD DBs accuracy	Three classifiers used with genetic algorithm for sparse representation for reducing the time.	Improve FRR and FAR with accuracy on real time applications

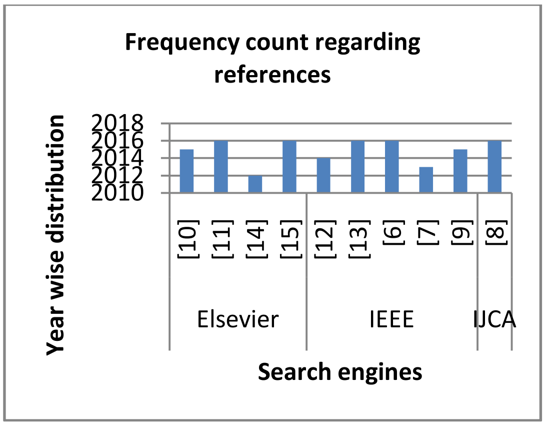

FIGURE 2. Year wise distribution of articles

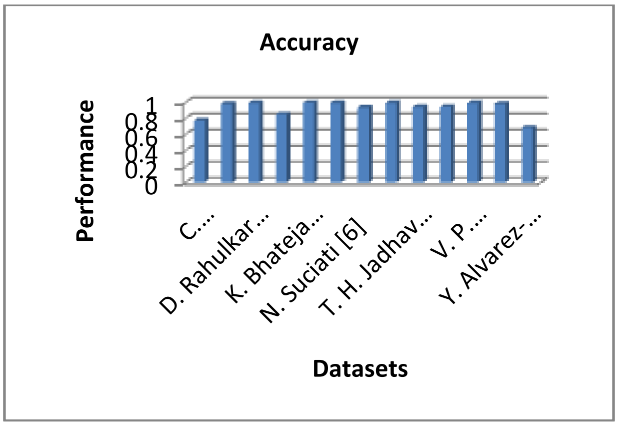

FIGURE 3. Accuracy performance measured by different datasets

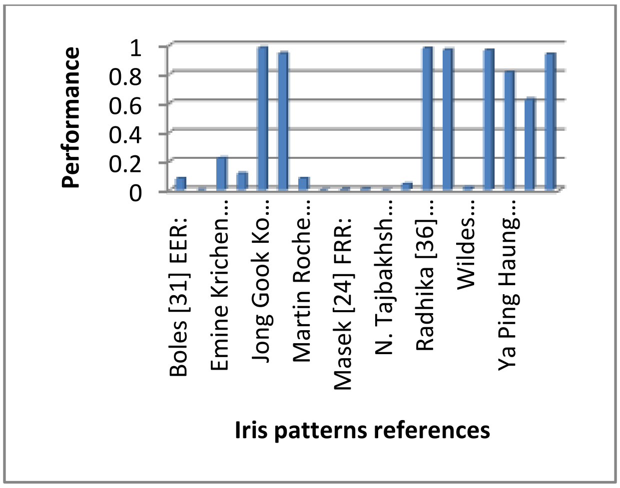

FIGURE 4. Iris recognition methods with their approved performance

5. CONCLUSION

This paper presents a comprehensive review of state-of-the-art techniques in iris recognition. It comprises of methodologies, algorithms and techniques related to this domain like feature extraction etc. Finally, the techniques have been evaluated in terms of efficiency. Different evaluation criteria have been employed to find the variations in the methods proposed so far in the literature and which method is better and in what capacity. The research also provides a wide range of other articles and average time along their algorithms, methods, procedures and approaches performance measure. It also includes the comparison of different researches outcomes and give a brief description about all. The survey can be a good platform for fresh and intermediate researchers in the field of iris recognition.

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