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A REVIEW ON IRIS AND PALM PRINT BASED UNIMODAL AND MULTIMODAL BIOMETRIC SYSTEM

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Abstract: Biometric systems have become one of the most reliable solutions for providing security in recent times. These are pattern recognition systems that verify or identify a person based on their physical or behavioural characteristics. Previously, most of the real world applications used unimodal systems, but they suffer from some limitations. These limitations were then ruled out by multimodal biometric systems which made them more reliable and secure. This paper presents a review on unimodal biometric system based on iris and palm print along with various feature extraction methods being applied on them. A comparative study is also presented on multimodal biometric system using iris and palm print.

Keywords: Unimodal, Multimodal, Biometrics, Security, Iris and Palmprint

1. INTRODUCTION

Biometric systems are the pattern recognition systems that use one or more physical or behavioural traits of the person to verify or identify him. These systems have evolved as one of the major solution in providing security in many real world applications. Talking about any field whether it be forensics, e-banking, driving licence issuing or even entering to any office or country, biometrics is gaining acceptance as most reliable and secure method of ensuring security. Security has become a major concern everywhere in our vastly interconnected society these days. Many traditional methods of providing security like passwords, user identities, ID cards, badges etc. seem not to be sufficient for security as these all traditional methods can easily be forged. Passwords, if disclosed (knowingly or unknowingly) to some unauthenticated person, can create serious problems. Even the person can sometimes forget his/her password or user identity also. Security can be easily breached if the person's ID card or badge gets stolen. Compromise with the security of the system due to failure of such applications can lead to a big loss sometimes.

Biometric systems ensure the authenticity of the person's identity by comparing some physical or behavioural traits of that person. It is the science of identifying a person correctly based on the features extracted from his biometric traits. These biometric traits can be physical trait, behavioural trait or combination of both. Physical traits are like iris, palm print, hand geometry, finger print, retina, height, face, hand vein etc. These are inherent, time invariant and very stable characteristics. On the other hand, behavioural traits depends upon some habits of the person or his behaviour like voice, signature, key stroke, walking speed, arm or leg movement etc. These are quantifiable characteristics that are developed with time and are more time variant [1]. Each trait has its own advantages and disadvantages over others. Suitable trait is chosen depending on the type of application, its environment and various factors like uniqueness, universality, performance, acceptability etc.

Biometric systems identify the authentic person on the basis of the features extracted from its biometric trait being used. This process of identification is divided into two phases i.e. enrolment phase and

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identification phase. Enrolment phase is the first phase of the operation of biometric system. In this phase, a feature set is extracted from the biometric trait being used based on requirement, type of application and some other parameters. This feature set is then stored in database as template for future reference. Second phase of operation of biometric system is identification phase. In this phase, features are again extracted from provided biometric trait and are compared with the one stored in the database during enrolment phase.

Based on the type of application for which biometric system is being used, the mode of operation of the system is defined. Biometric systems can operate in two modes i.e. identification mode and verification mode [3, 4]. Identification mode, also known as one-to-many matching mode is used when identity of the person is unknown and we have to find the same. In such applications, the provided biometric is compared with every template stored in the database to find out the identity of the person related to that biometric. Forensic cases, criminal cases etc. aresome examples of such applications. This mode of operation is very useful in negative recognition [2], where the system ensures if the person is who he denies to be (intentionally or unintentionally). Verification mode, on the other hand, is one-to-one matching mode. In this mode, system verifies the identity of a person by comparing his captured biometric with the biometric stored in the database as template. Here identity of the person is already known and comparison is done just to verify his identity with his own stored biometric, so it is called one-to-one matching. This is helpful in preventing multiple people using same identity. Applications like E-banking, phone or laptop security applications, building or office entry security systems etc. are some examples of verification mode of biometric systems.

Depending upon the number of biometric traits used for identification, biometric systems are classified as unimodal and multimodal biometric systems.Unimodal biometric systems rely upon single biometric trait for identification of the person. This makes unimodal systems suffer from a lot of limitations like:

(i) ***Noisy sensor data:*** It is where acquired biometric data can be noisy. Main reason behind this type of problem is dirty, defected sensors, different type of sensors used for capturing biometric trait at different times or improperly maintained hardware systems

(ii) ***Non-universality:*** Universality means every person present in the population is able to be recognized by that biometric trait. Not every biometric trait is purely universal

(iii) ***Lack of individuality:*** This means features extracted based on one modality can go similar for a few person in the population like father and son or identical twins can have same facial structure etc.

(iv) ***Lack of invariant representation:*** Biometric trait information obtained from the user during verification can go different from the data collected during enrolment

(v) ***Spoofing:*** Although it seems very challenging to steal someone's biometric trait, but still with today's advanced and interconnected technologies, it is possible to circumvent biometric system using spoofed biometric trait [5, 6]. To overcome all these limitations multimodal systems are used. These are the systems which uses two or more modalities to identify or verify a person which helps these systems to solve most of these limitations, most importantly spoofing.

Biometric systems, whether it be unimodal or multimodal, have four basic modules [7] i.e. sensor module, feature extraction module, matching score module and decision making module as shown in Figure 1.Sensor module is the first module of biometric system. It is the interface for the person whose biometric trait is to be captured. Here the required biometric trait is captured using some hardware tools like sensors, cameras, retina scanners or some other complex machine, depending upon the requirement of the application. The image produced in this module is used for identification in further modules. Feature extraction module is the second module that uses the output image of sensor module to extract feature set from that image for further reference. That feature set is stored in database as template and matching is done with this feature set for identifying the person. This module plays a critical role in the system as the performance and accuracy of the system depends upon the type of feature set extracted here. Matching module is the one where classification is done on the basis of features extracted in last module. Here the acquired feature vector is compared with the stored feature vector and accordingly, matching score is generated. This matching score further helps in taking the decision. Decision makingmodule is the final step in the biometric system. Here final decision is made on the basis of the matching score generated in last module. Based on that, the claimed identity will either be accepted or rejected (in verification mode) or the person is identified (in identification mode) [2].

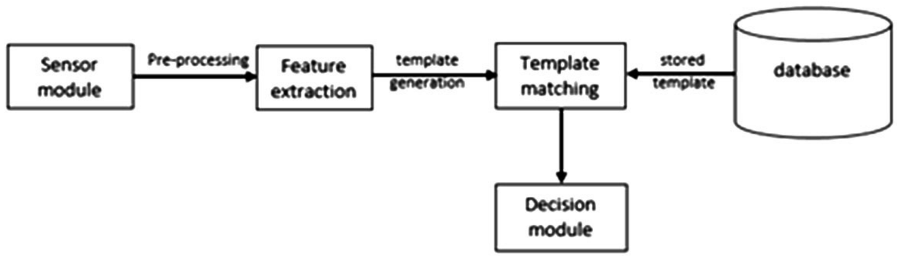

Figure1. Architecture of a biometric system

Since multimodal biometric system makes use of two or more biometric traits, information from these traits need to be fused at some point to get the final result. This fusion is possible at three different levels i.e. fusion at feature extraction level, matching score level and decision level [6, 7].Fusion at feature extraction level: In this level, captured data or the features extracted from them are fused together to get the results. Fusion at this level gives the best results as direct image or its feature vector is richest in information. But this is the most difficult one to apply as feature vectors from various biometrics may not be compatible with each other. Fusion at matching score level: Here score results of various matching classifiers are fused to generate the final result. This method of fusion is most widely used because of ease of access and better results. Fusion at decision making level: Different results of acceptance/rejection are produced corresponding to each traits using feature vectors and classifiers and then finally, those decisions are combined through voting scheme to take the final decision. All these fusion levels are shown in Figure 2.

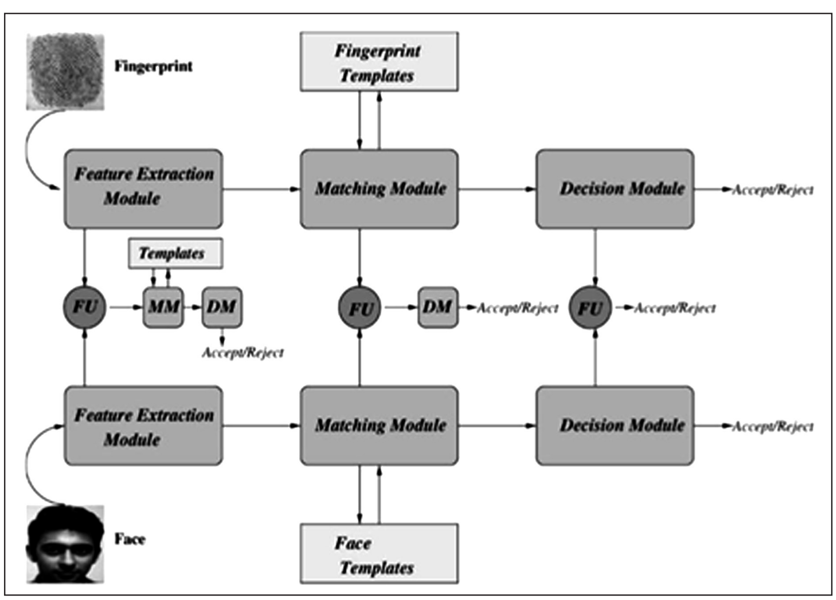

Figure 2: Showing various fusion levels possible (FU: fusion module, MM: matching module, DM: decision module) [7]

This paper reviews various techniques related to unimodal systems based on iris and palm print individually. It also presents a review on various feature extraction techniques applied on multimodal biometric systems. Also different fusion levels and their corresponding methods are discussed. For this review, two biometric traits are chosen i.e. Iris and Palmprint. Reason for choosing iris was its uniqueness property for every individual [8, 9]. It is proved that even a person's left and right iris has different texture patterns. Also iris is easy to capture as compared to traits like retina. Similarly, palmprint also has the property of uniqueness in it. Also, it provides a wide area for feature extraction than other biometrics such as finger print etc. It also provides stability as only a little changes occur in features like principle lines, delta points, in long duration of time.

2. LITERATURE REVIEW

2.1 Review on Iris

Iris is the round shaped region in human's eye surrounded by pupil and sclera on both sides. It started gaining popularity as an effective biometric trait during last decade. Iris is proved to be most unique trait for identification as probability of two iris to be same is 1/1051 according to J. Daugman [10].In 1987, Leonard Flom and Aran Safir [11] first used iris as a biometric trait for person's recognition. Since then, many methods were formulated to extract iris region from whole eye image like circular hough transform used by Ma, Li et al. [12]. Template matching was done using exclusive OR technique in the same. John Daugman et al. [13] developed very successful algorithms for person's recognition using iris. Few other algorithms were also developed after that as an alternative to the commercial, expensive and complex Daugman algorithm [14, 15]. One of those algorithms, which gained much popularity is RED (Ridge energy detection) algorithm. This algorithm used local statistics of iris for segmentation and stored extracted features into horizontal and vertical polar coordinates, then used hamming distance for matching.

Meanwhile, many other methods were also developed like active contour method for iris localization by J. Daugman [16], feature extraction using Gabor filters [18]. Iris recognition required full cooperation from user, this came out as a major issue regarding the trait. Images taken in unconstrained environment could create problems in recognition. Tan, Tieniu et al. [17] proposed an algorithm to solve this problem in 2009. They used clustering based coarse iris localization and integrodifferential constellation was developed for pupil extraction. Santos et al. [19] proposed algorithm based on 1-D and 2-D wavelets for unconstrained environment. Another algorithm using K- mean clustering, circular hough transform for localization and canny edge detector was developed in 2013 [20]. N. Kaur and M. Juneja [21] developed an algorithm using Fuzzy c-mean clustering, canny edge detection and circular hough transform for unconstrained environment. Amrata et al. [9] proposed method using Circular hough transform, DCT (Discrete cosine transform) for feature extraction and feed forward neural networks as classifier. Some of the algorithms and their performance measures such as accuracy, FAR (false acceptance rate), FRR (false rejection rate), ERR (equal error rate) are shown in table 1. This table shows that J. Daugman's algorithm gives best results till now.

Table 1
Comparison between various algorithms for iris recognition

Author	*Accuracy*	*FAR/FRR*	*ERR*
J. Daugman [13]	99.9%	0.01/0.09	0.95
Kaushik Roy [24]	99.5%	0.03/0.02	0.92
Navjot [21]	98.80%	98.80%	
Li Ma [12]	98.00%	0.02/1.98	4.73
Avila [22]	97.89%	0.03/2.08	3.38
Tisse [23]	96.61%	1.84/8.79	

2.2 Review on Palm print

Palm print is another part of human body which is being used as a biometric trait successfully. It gained popularity as a biometric trait in last decade due to its properties like uniqueness as even identical twins have different palm prints, being less time variant as compared to traits like face, height and wide room for selecting and extracting features as compared to traits like finger print. Capturing image for obtaining biometric is also quite easy and cheap in this case [26, 27].Palmprint recognitioncan be employed on either high or low resolution images. High resolution images of palm are used in forensic or high security applications for example criminal detection [28]. Whereas commercial applications such as access control find low resolution images more suitable. Palm features are classified in five different classes i.e. geometric, line, point, texture and statistical. Various feature extraction algorithms have been developed based on what type of features are to be selected from these five. Major work on this biometric trait was started by A. Jain et al. [29] in 2001. They proposed algorithm that used prominent principle lines and feature points of palm image. Palmprint has also been successfully used in online systems for identification of person using 2D Gabor filters for feature extraction [30].

Many other algorithms were presented using techniques like Sobel operator, HMM (hidden markov model) classifiers [32] for identification that gave up to 98% (approx.) identification rate [31, 33].They worked on line features of palm print. Table 2 gives some short information on above work done.

Table 2.
Few algorithms using line features of palm print.

Author	*Dataset size (persons)*	*Classifier used*	*Accuracy*
Xiangqianet al. [32]	320	HMM	97.80%
Wong et al. [33]	100	Hamming distance	94.84%

Different techniques like PCA (principle component analysis) and ICA (independent component analysis) were used to work on statistical features of palmprint [34].Statistical features can be of local or global approach [28]. Local statistics are like mean, variance etc. of small regions of transformed hand image. Global approaches like centre of gravity, density etc. works directly on whole transformed image without breaking it into small portions. Similarly, many other algorithms based on methods like DCT [35], Contourlet transform [37], Fourier transform [36], Scale invariant feature transform for contactless images [38] were also proposed. From all these, DCT gave more accuracy for extracting features like principle lines [27] and centric point of palm using Euclidian distance. S Chakraborty et al. used texture features of palm by 1D DTCWT (dual tree complex wavelet transform) and BPNN (back-propagation neural network) binary classifiers for matching purpose [26]giving up to 98.35% accuracy. Table 3 gives information about some of the work done on texture features of palm.

Table 3
Few algorithms using texture features of palm print.

Author	*Dataset size (persons)*	*Classifier used*	*Parameters*	*Values*
Li et al.[36]	500		Identification rate	95.48%
Butt et al.[37]	386	NED	GAR Decidability index EER	88.91% 2.7748 0.233%
S Chakraborty et al.[26]	50	BPNN-GDX	Accuracy	98.35%

Shefali et al. [39] used geometric features of palm for developing multimodal system of palm print and hand geometry. Score level fusion was used to obtain 0.31% EER (equal error rate) for JUET contact database and 0.52% for IITD contactless database.Another method based on geometric features was developed using support vector machine [40]. They evaluated their system on the basis of FAR (false acceptance rate) and FRR (false rejection rate). Table 4 gives information about work done on geometric features.

Table 4.
Few algorithms using geometric features of palm print.

Author	*Dataset size (persons)*	*Parameters*	*Values*
Shefali et al. [39]	50 (JUET)	EER	0.31%
	240 (IITD)		0.52%
GafarZenAlabdeen Salh et al. [40]	168	FAR	33.3%
		FRR	73.3%

2.3 Review on iris and palmprint (fusion)

In 1998, Hong and A. Jain [41] integrated face and finger print for developing a multimodal identification system which overcame all the limitations of face recognition system and finger print recognition system. They proved that multimodal systems give better overall performance than unimodal systems using same biometric traits.

Similarly, iris and palm print individually face some limitations, that can be targeted using multimodal biometric system using both iris and palm print. Both of the traits are proved to be quite good for identification purpose and have been used a lot for the same. But now, multimodal systems are gaining popularity due to their better performance results. Overall accuracy of a multimodal system depends on a lot factors like type of feature set selected from each modality, fusion level being used, fusion method being used, image resolution used, feature vector compatibility etc. In 2007, Xiangqian et al. fused iris and palmprint for developing personal authentication system. The author performed score level fusion using sum and product techniques resulting in 0.012% MTR and 0.006% EER. Hariprasath et al. [43] in 2012, developed multimodal system using iris and palm print for identification purpose. Feature level fusion is performed using wavelet packet transform technique resulting in accuracy up to 93.00%. R. Gayathri et al. also used texture feature extraction in the same year to develop algorithm for wavelet based feature level fusion with an accuracy of 99.2% and FAR of 1.6% [44].

In 2014, Kihal et al. worked on three different datasets in their experiment to prove that the quality of the input image also influences the accuracy rates [45] and performed all three levels of fusions separately in their experiment for comparing the results and used texture features of iris and palmprint. Among all experiments performed by them, decision fusion gave best results with 100 % GAR and a very small FAR. SD Thepade et al. developed algorithm for same trait in 2015, in transform domain instead of spatial domain [46], they worked on texture features but used score level fusion and extracted features using Haar, Walsh and Kekre transform. According to their findings, Kekre transform performed better in all three with a GAR of 51.80 (approx.). Another algorithm developed by Apurva et al. was [8] based on techniques like RED algorithm, Harris feature extraction algorithm in 2015. They worked on geometric features of palm and choose decision level fusion for final outcomes. Some of the work done on these two modalities is shown in table 5 along with their fusion levels and respective methods used and different evaluation parameters.

Table 5.
Comparision between fusion algorithms.

Author	*Dataset size (persons)*	*Fusion level*	*Fusion method*	*Parameters*	*Values*
Xiangqian et al. [42]	120	Score level fusion	Sum, product, maximum, minimum strategies	MTR EER	0.012% 0.006%
Hariprasath et al. [43]	30 (iris) 20 (palm print)	Feature level fusion	Wavelet Packet transform, Concatenation	Accuracy	93.00%
R. Gayathri et al. [44]	125	Feature level fusion	Wavelet based technique	Accuracy FRR	99.2% 1.6%
Kihal et al. [45]	200	Feature fusion, Score fusion, Decision fusion	Concatenation, Sum rule method, Error fusion	GAR FAR[1] FAR[2]	100% 2.10^{-3}% 4.10^{-4}%
Thepade et al. [46]	10	Score level fusion	Mean square error method	GAR	50.20 (Walsh) 51.80 (Kekre) 50.20 (Haar)
Apurva et al. [8]	7	Decision level fusion		RR	100% (iris) 100% (palmprint)

1 FAR value for fusion of iris and CASIA palmprint database [45]

2 FAR value for fusion of iris and PolyU palmprint database [45]

3. CONCLUSION AND FUTURE WORK

This paper provides a review on unimodal systems based on iris and palm print individually as well as on multimodal systems based on their fusion. It can be easily seen that multimodal systems provide better overall performance as compared to unimodal systems.Iris and palmprint both being difficult to get forged and complex for feature extraction, has come out as a very successful combination for multimodal biometric systems.Many researchers proposed various algorithms based on iris recognition from which J. Daugman's algorithm gave best results till now with 99.9% accuracy [13]. Palm-print features are divided in five categories, among those texture features give better results [26]. Combination of these two traits have given 99.2% accuracy [44]so far. Some areas where more work can be done in future are feature extraction of palm-print, fusion level methods etc. Further work can be done on background extraction using single algorithm for all kind of hand images. Combination of two or more categories, for example texture and geometrical, can be used for better results. Performance improvement in the system, if any, can also be tested by applying different feature level, score level, decision level fusion methods.

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