Fusion of Iris Feature and Palm print Features for security applications

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***Abstract*– A Biometric system is essentially a pattern recognition system that makes use of biometric traits to recognize individuals. Authentication systems built on only one biometric modality may not fulfill the requirements of demanding applications in terms of properties such as performance, acceptability and distinctiveness. Most of the unimodal biometric systems have problems such as noise in collected data, intra-class variations ,inter-class variations, non universality etc. some of these limitations can be overcome by multiple source of information for establishing identity; such systems are known as multimodal biometric systems. In this paper a multimodal biometric system of iris and palm print based on wavelet packet analysis is described. The most unique phenotypic feature visible in a person's face is the detailed texture of each eye's iris. Palm is the inner surface of a hand between the wrist and the fingers. palm print is referred to principal lines, wrinkles and ridges on the palm. The visible texture of a person's iris and palm print is encoded into a compact sequence of 2-D wavelet packet coefficient, which generate a "feature vector code". \in this paper, we propose a navel multi resolution approach based on Wavelet Packet Transform (WPT) for texture analysis and recognition of iris and palm print. The development of this approach is motivated by the observation that dominant frequencies of iris texture are located in the low and middle frequency channels. With an adaptive threshold, WPT sub images coefficients are quantized into 1,0or-1as iris signature. This signature presents the local information of different irises. By using wavelet packets the size of the biometric signature of code attained is 960 bits. The signature of the new pattern is compared against the stored pattern after computing the signature of new input pattern. Identification is performed by computing the hamming distance**.

***Keywords*—Biometric, iris pattern, palm print, multimodal, wavelet packet transform, score level fusion**

1. INTRODUCTION

The word iris is generally used to denote the colored portion of the eye. It is a complex structure comprising muscle, connective tissues and blood vessels [1]. The image of a human iris thus constitutes a plausible biometric signature for establishing or confirming personal identity. Further properties of the iris that makes it superior to finger prints for automatic identification systems include, among others, the difficulty of surgically modifying its texture without risk, its inherent protection and isolation from the physical environment, and its easily monitored physiological response to light. Additional technical advantages over finger prints for automatic recognition systems include the ease of registering the iris optically without physical contact. Besides the above fact, the process of feature extraction is easier due to its intrinsic polar geometry.

Palm is the inner surface of a hand between the wrist and the fingers. Palm print is referred to principal lines, wrinkles and ridges on the palm. The principal lines are formed between the 3rd and 5th months of pregnancy and superficial lines appear after we born. Although the principal lines are genetically dependant, most of the other creases are not so. Even identical twins have different palm prints.

Palm print has been used as a powerful means in law enforcement for criminal identification because of its stability and uniqueness. The rationale to choose hand features as a base for identity verification is originated by its user friendliness, environment flexibility and discriminating ability.

11. EXISTING METHODS

The first successful implementation of iris recognition system was proposed by J.Daughman in 1993[3]. This work though published more than 29 years ago still remains valuable since because it provides solutions for each part of the system. It is worth mentioning that most systems implemented today are based on his work. They are based on Gabor wavelet analysis [1] [2] [3] in order to extract iris image features. It consists in convolution of image with complex Gabor filters. As a product of this operation, phasors (complex coefficients) are computed. In order to obtain iris signature, phasors are evaluated and coded by their location in the complex plane. However the Daugmen"s method is patented which blocks its further development.

In another approach suggested, by Lye Wil Liam and ali Chekima in their paper [4], the iris image is pre processed for contrast enhancement. After preprocessing, a ring mask is created and moved through the entire image to obtain the iris data. By using this data the iris and pupil are reconstructed from the original picture. Using the iris center coordinate and radius, the iris was cropped out from the reconstructed image. The iris data(iris donut shape) is transformed into a rectangular shape. Using a self organized feature map the iris pattern is matched. The network contains a single layer of Euclidean weight function. Manhattan distances are used to calculate the distance from a particular neuron X to the neuron Y in this neighborhood. Manhattan
distances without a bias and a competitive transfer function is used to upgrade the weight.

In another method followed by Jie Wang [7] the iris texture extraction is performed by applying wavelet packet transform (WPT) using Haar wavelet. The iris image is decomposed in to sub images by applying WPT coefficients are encoded.
K.Grabowski and W.Sankowski have designed another mehod for iris features extraction method. In their paper [8], Haar wavelet based DWT transform is used.

Ajay kumar and Helen C. Shen [9] proposed an approach in which Gabor filter is used for palm print recognition. Fang Li et al. [10] proposed an approach utilizing Line Edge Map (LEM) of palm print as the feature and Hausdorff distance a s the distance matching algorithm.

The content of this paper is organized as follows. Section III describes the steps involved in multimodal Recognition system. Section IV presents our proposed approach using Wavelet packets based approach. Section V gives the result of Wavelet packet Transform based approach on the iris and palm print database. Finally, conclusions and perspectives are given in section VI.

III. MULTI MODAL BIOMETRIC SYSTEM

A generic biometric system has 4 main modules namely a) Sensor module, b) Feature extraction module, c) Matching module, d) Decision module. In a multimodal biometric system, information reconciliation can occur in any of the previously mentioned modules as a) fusion at the sensor level where the combination of raw biometric data takes place, b) fusion at data or feature level,(data/features) where combination of different feature vectors are obtained, c) Fusion at the match score level, d) Fusion at the decision level. It is shown in figure 1.

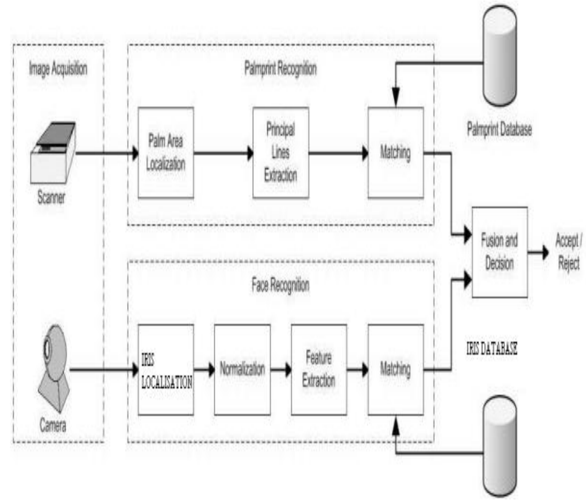

Figure 1. Scenario in a multi modal biometric system

In this paper fusion at feature level is presented. Feature vectors are obtained from iris data and palm print separately and then fused. Finally matching is performed and decision is taken,

A. Iris recognition System

An iris recognition system can be decomposed into three modules : an iris detector for detection and location of iris image, a feature extractor to extract the features and a pattern matching module for matching. The iris is to be extracted from the acquired image of the whole eye. Therefore, before performing iris pattern matching, the iris is to be localized and extracted from the acquired image.

a) Iris Localization

The first step is iris localization. Using the Integrao differential operator (IDO) (I) the iris is localized.

$$\max_{(r,x0,y0)} \left| G_\sigma * \frac{\partial}{\partial r} \oint_{r,x0,y0} \left(\frac{I(x,y)}{2\pi r} \right) ds \right| \qquad (1)$$

Where I(x,y) is a raw input image. The IDO (1) suggested by J.Daughman [1] [2] searches over the image domain (x,y) for the maximum in the blurred partial derivative with respect to increasing radius r, of the normalized contour integral of I(x,y) along a circular arc ds of radius r and center coordinates (x0,y0). The symbol * denotes convolution and G_σ ®

is a smoothing function such as a Gaussian of scale σ. It searches iteratively for the maximal contour integral derivative at successively finer scales of analysis through the three-parameter space (x0,y0,r) defining a path of contour integration. It finds both papillary boundary and the outer boundary of the iris. The results are shown in figures 2 to 5.


Figure 2. Iris Image 1


Figure 3. Iris Image 2


Figure 4. localisation of iris Image 1

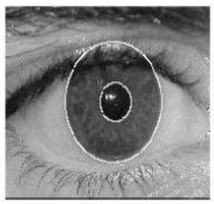
Figure 5. Localisation of iris Image 2

b) Iris Normalization

After the iris is localized the next step is normalized (iris enrollment). Using the equations (2) the iris data are extracted. Different circles with increasing radius and angle arre drawn starting from the pupil centre till it reaches near the iris coordinates. The information is extracted.

$x = c(x) - r*\sin(\Theta)$
$y = c(y) - r*\cos(\Theta)$

where c(x,y) denotes center coordinates, (x,y) denotes coordinates of the image, Θ is the angle and r denotes the radius. Figure 6 and 7 shows the extracted (normalized) iris data.

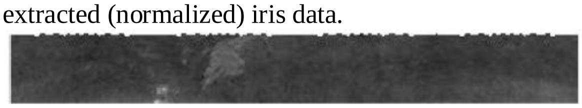
Figure 6. Normalized data (Extracted iris data) of iris image 1


Figure 7. Normalized data (Extracted iris data) of iris image 2

c) Wavelet Packet Transform (WPT Approach)

The standard discrete wavelet transform (DWT) is a very powerful tool used successfully to solve various problems in signal and image processing. The DWT breaks an image down into four sub-sampled images. The results consist of one image that has been high passed in the horizontal and vertical directions (HH), one that has been low passed in vertical and high passed in the horizontal (LH), one that has been high passed in the vertical and low passed in the horizontal (HL) and last that has been low pass filtered in both directions (LL) where, H and L mean the high pass and low pass filter, respectively. While HH means that the high pass filter is applied to signals of both directions, represent diagonal feature of the image, HL correspond to horizontal structures, LH correspond to vertical information and LL is used for further processing.

Wavelet packets Transform (WPT) is a generalization of wavelet Transform that offers a richer signal analysis. With WPT, it is possible to zoom into any desired frequency channels for further decomposition. Compared with WT, WPT offers a finer decomposition. When processing some oscillating signals, partition of low frequency parts is not fine enough. WPT can overcome this problem via decomposing high frequency components and more details obtained in WPT yield better representation of signals. As a progressive texture classification algorithm, WPT gives reasonably better performance because the dominant frequencies of iris texture are located in the low and middle frequency channels.

Biometric texture extraction with WPT and encoding procedure involves three steps:

1. Decomposition. At each stage in the decomposition part of a 2-D WPT, four output sub images are generated. The images contain approximation (A) ,horizontal detail (H), vertical detail (V) and diagonal detail (D) coefficients respectively. After 3-level WPT, an image has a quad tree with 64 output sub images, each representing different frequency channels [11]. It is shown in Figure 8.

2. Selection of sub images for feature encoding

Processing wavelet coefficients of every sub image is a fair amount of work; furthermore, some of them are representations of high frequency noise which reduce our ability to distinguish each iris. It is advisable to choose a subset of all possible sub images to make our encode process. The useful sub images with entropy criterion to make our analysis much more efficient and just as accurate using (3).

$$Entropy = -\sum_{i}\sum_{j} S_{i,j}^2 \log(S_{i,j}^2)$$

In equation (3) $S_{i,j}$ is the coefficient of the sub image. It is found that sub-image 10 retains higher entropy than other sub images. Hence it is chosen as the candidate sub image for feature extraction.

3.Iris Feature encoding

A code matrix can be achieved by quantizing the coefficients of candidate sub image and LL3, HL3 or LH3 into one data element each with a suitable threshold T as shown in equation (4).

$$C_{ij}=1 \text{ if } S_{ij}>T;\ C_{ij}=0,\ |S_{ij}|<T;\ C_{ij}=-1,\ S_{ij}<\text{-T}; \qquad (4)$$

Where sij is the coefficient of a sub image, cij is the corresponding code element and t is threshold is a positive number. Equation (4) has 2 abilities of de-noising and finding singular points. T is chosen as T=3 **σ** and **σ** is the variance of the noise. It is reported that the Standard Deviation of the WPT high frequency coefficients (sub-image 84) are having the good estimation of **σ** . The code matrix gives a good description of both frequency and location content of an image. The chosen sub image is called candidate sub-image.

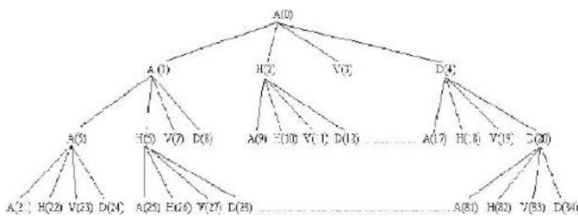

Figure 8. Wavelet packet decomposition

4. *Iris Matching* for matching the biometric codes Modified Hamming Distance HD as shown in (5) is Used.

$$HD=\frac{codeA \otimes codeB}{n} \qquad (5)$$

In equation (5) codeA and codeB are the iris codes of 2 iris to be compared, (8) denotes bit wise exclusive OR operation and n is number of bits in code A.

B. *Palm print Recognition System*

Before feature extraction, it is necessary to obtain a sub-image from the captured palm print image and to eliminate the variations caused by rotation and translation. After extracting the sub image as region of extraction by preprocessing, the texture features of the palm prints are extracted by Gabor filters decomposition scheme. The Gabor filter is an effective tool for texture analysis and has the following general form.

$$G(x,y,\mu,\omega,\theta)=\frac{1}{2\pi\sigma^2}\exp\left(\frac{-x^2+y^2}{2\sigma^2}\right)\exp(2\pi i)(\mu x\cos\theta+\mu y\sin\theta) \qquad (6)$$

where i = -1, u is the frequency of the sinusoidal wave, q controls the orientation of the function and s is the standard deviation of the Gaussian envelope. The sample point in the filtered image as shown in Figure 9 is coded in to two bits (b" bi) . Depending on the phase value of complex vector generated, using table 1 phase bits are generated. Thus palm print code of 960 bits is generated.

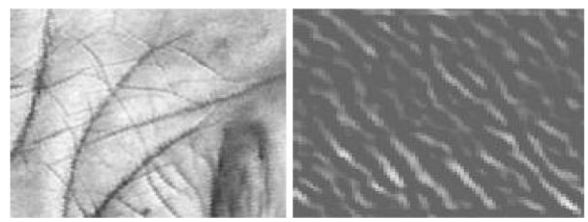

Figure 9. Preprocessed pal m print and extracted palm print features

IV. MULTI MODAL BIOMETRIC SYSTEM

In this particular approach, the iris images are encoded using wavelet packets to formulate a template. The palm print images are encoded using Gabor filters. Instead of traditional multi resolution analysis (MRA) scheme, a novel lifting technique is used to construct the biorthogonal filters[8].

The main advantage of this scheme over the classical construction is that it does not rely on the Fourier transform. Also, it allows faster implementation of wavelet transform. The basic idea behind the lifting scheme is shown in Figure l0.

It starts with trivial wavelet, the "Lazy wavelet"; which has the formal properties of wavelet, but is not capable of doing the analysis. The lifting scheme then gradually builds a new wavelet, with improved properties, by adding in a new basis function.

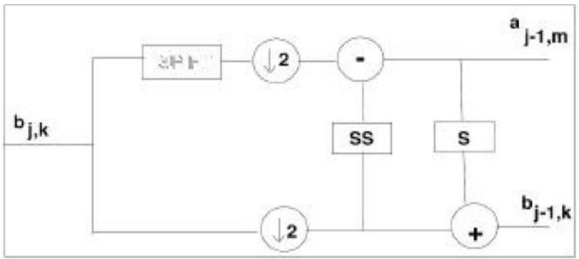

Figure 10. Lifting scheme

The lifting scheme then gradually builds a new wavelet, with improved properties, by adding in a new basis function. The lifting scheme can be visualized as an extension of the FIR (Finite Impulse Response) schemes [8].

It first calculates the Lazy wavelet transform, then calculates the $a_{i-1,m}$ and finally lifts the b_{j-1-k}. It is known that any two-channel FIR sub band transform can be factored into a finite sequence of lifting steps. Thus, implementation of these lifting steps is faster and efficient. The biorthogonal filter family is shown in Figure 11 [11]. The frequency content of the resulting coefficients is adjusted each time to get separated band structure.

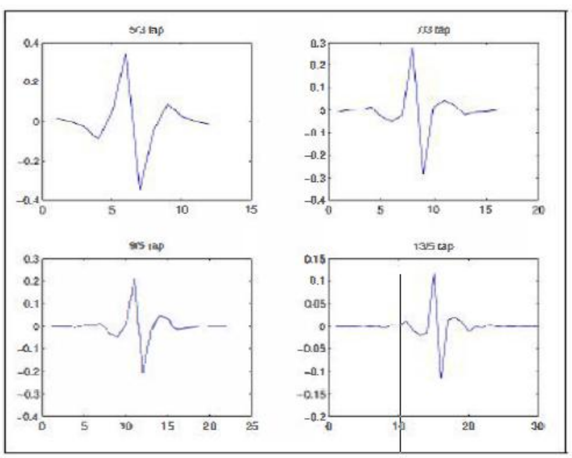

Figure. I I Biorthogonal filter family

For fusion of feature vectors from iris and palm print concatenation and shifting technique is used. In this work we have used Symlets and Biorthogonal as mother wavelets for constructing iris feature vector. We have decomposed the normalized image up-to third level of decomposition. In order to create the feature vector we tried different combinations of LH3, HL3, and HH3 with candidate sub-images (of iris and palm print). The results obtained from different combinations are compared to find the best. The binary feature vector that is generated by quantizing the feature vector obtained by the combination of LH3, HH3 with the candidate sub-image is found suitable for encoding in our work.

V. RESULTS

From UBIRIS database, 8 different iris images of 30 persons are taken (240 samples of iris) and code matrix is formed. From UBIRIS database of palm print, 8 different palm images of 20 persons are taken and code matrix is formed. By concatenation and shifting the feature vector s are fused. When a new iris and palm image are presented as an input, the code matrix of the images is found out. Using the modified hamming distance, the pattern matching is performed. Based on this value, the class to which the new image belongs to is calculated. With this information the False Acceptance Ratio (FAR) and False Rejection Ratio (FRR) for each class are calculated for testing images. The recognition performance of iris feature alone using wavelet packet transform is given in table 1. The calculated False Acceptance Ratio (FAR) and False Rejection Ratio (FRR) using Gabor wavelets are given in Table 2.

TABLE I. RECOGNITION PERFORMANCE OF IRISFEA TURE VECTOR USING DIFFERENT MOTHER WAVELETS

Recognition performance		
Wavelet type	*Accuracy in %*	*Feature vector length*
Sym2	*81.50*	*288*
sym3	*90.50*	*480*
sym4	*89.00*	*460*
sym6	*90.00*	*640*
sym8	*91.50*	*960*
bior 1.5	*92.00*	*640*
bior 2.6	*85.00*	*480*
bior 3.9	*93.00*	*1280*

TABLE II. RECOGNITION PERFORMANCE OF PALM PRINT FEATUREVECTOR

Palm print recognition performance						
Threshold	*0.8276*	*0.7589*	*0.6691*	*0.5646*	*0.7648*	*0.6399*
FAR	*89%*	*73%*	*40%*	*14%*	*76%*	*31%*
FRR	*6%*	*23%*	*49%*	*77%*	*20%*	*57%*

TABLE Ill. PERFORMANCE OF FEATURE VECTOR FOR MULTI MODAL BIOMETRIC

Modality	*Accuracy in %*	*Feature vector length*
Iris	*91.50*	*960*
Palmprint	*89.46*	*960*
Combination of Iris and Palmprint	*94.42*	*960*

The Performance of the proposed iris recognition system using Symlets and biorthogonal wavelets are shown in the figures 12,13. In these figures classes refer to the image classes of iris images. Class 1 refers to the user 106 and class 8 refers to user113.

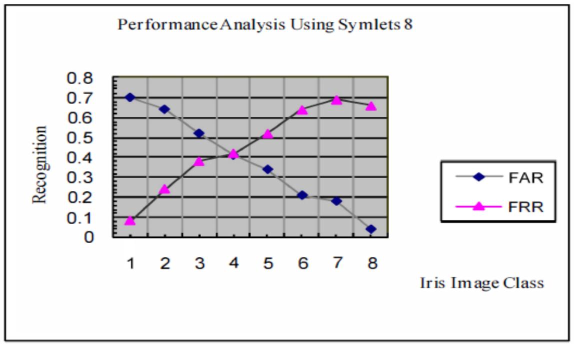

Figure. 12 Iris recognition performance using symlets

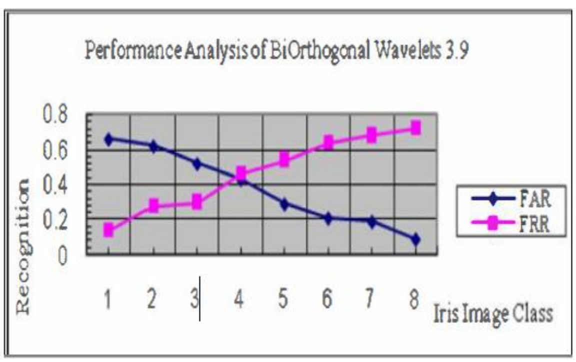

Figure.13 Iris recognition performance using Biorthogonal wavelets

From the figures 12 and 13 it can be seen that the EER value of recognition system decreases as the mother wavelet chosen is varied. For Symlets wavelets the EER value is 0.41 whereas for biorthogonal wavelets the EER is 0.39. The accuracy of the proposed system varies when different feature vector isc hosen. The performance curve of the system in term of accuracy for feature vector using various mother wavelets are is shown in figure 14.

The performance analysis of palm print recognition system using Gabor filters are shown in figure 15. By choosing the 3rd scale and 3'd orientation filtered image as candidate image for encoding, the FAR and FRR are calculated and EER obtained is 0.42%. This value is found to be high. To improve the EER value, further the palm print input image is filtered using other scales. When Gabor filter of scale 6 and orientation 3 is used, low EER rate obtained as 0.26%. It is shown in figure 16.

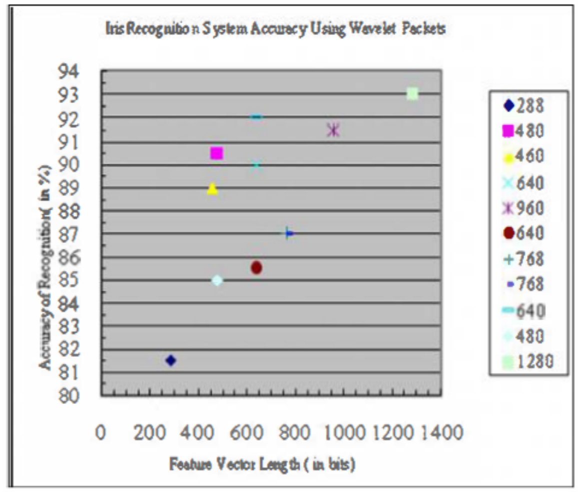

Figure.14 Iris recognition system performance in terms of feature vector length

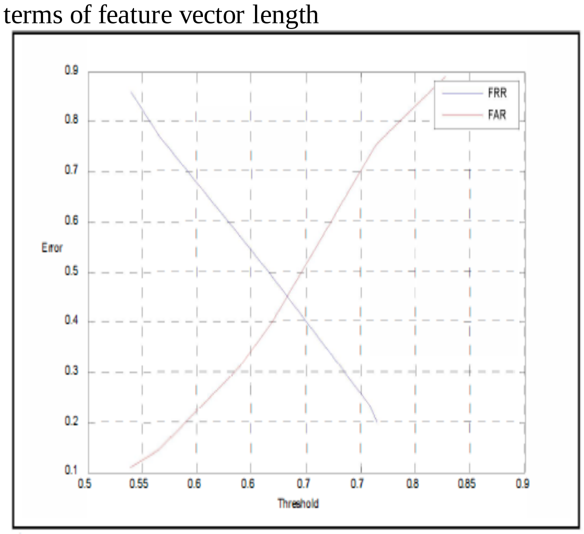

Figure.15 performance analysis of palm print recognition using Gabor filter

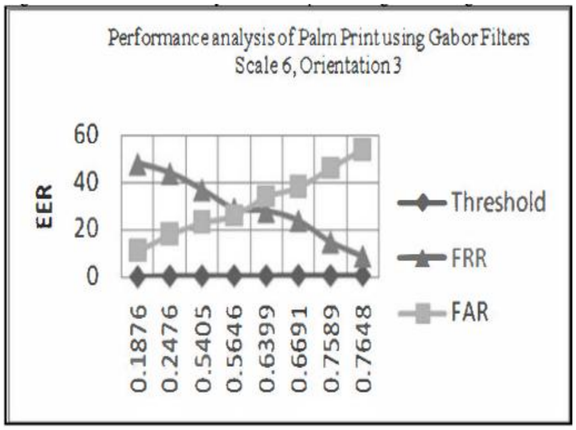

Figure 16. Performance analysis of palm print recognition using Gabor filters with scale 6, orientation 3

VI. RESULTS

The experimental results clearly demonstrate that the feature vector consisting of concatenating the candidate sub image, LH3 and HH3 (forming iris feature vector) and 3rd orientation of 6th scale decomposed palm print feature vector gives better results. By the fusion of matching of palm print and iris feature vector, score of overall recognition is improved. On the other hand, the Symlets wavelet is Particularly suitable for implementing high-accuracy iris verification identification systems, as feature vector length is at the least compared to other wavelets. The Coiflets wavelets gives better EER performance compared to other wavelet packets. But the feature vector size is little high compared to biorthogonal wavelets. For a reduction of 3% accuracy, the length of the feature vector and no of bits required to represent the iris signature is reduced substantially in the case of biorthogonal wavelets. The bior3.9 wavelet gives an accuracy of 93.00% but the feature vector length is approximately 5 times larger compared to feature vector obtained using Symlets wavelet By combining the iris and palm print recognition scheme the accuracy of the recognition is improved .

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