Palmprint Recognition Using PCA and Weighted Feature Level Fusion of 2D–Gabor and Log-Gabor Features

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ABSTRACT

Palmprint biometric technology is most accurate and reliable, which has acquired good impact over the remaining biometric technologies. Palmprint contains various features like minutiae points, wrinkles, palm lines and texture, etc. A Number of line based approaches, subspace based approaches and texture based methods for extracting features from Palmprint have been considered and studied thoroughly. This paper presents a multi-algorithm based Palmprint recognition system. In which, from preprocessed palmprint image features are extracted by means of 2D-Gabor filter and Log Gabor filter. The system performance has been evaluated by considering each texture features individually. Then, these texture features are combined using weighted feature level fusion. As fusion at feature level leads to high dimensional data, Principal Component Analysis (PCA) has been applied to reduce the dimension. Based on Euclidean distance the palmprints have been matched. The experiments have been done on IIT Delhi database. And the results had shown that the proposed system has significant improvement in accuracy when compared against individual recognition systems.

Keywords: Palmprint, 2D-Gabor Filter, Log Gabor Filter, PCA, Weighed Feature Level Fusion

I. INTRODUCTION

The tremendous developments in society of information have been driving towards a reliable and secure identification of an individual. Here biometrics plays a key role in identification because of its reliable, stable and unique characteristics [1]. In the family of biometrics, the identification systems make use of either behavioural characteristics (like gait, signature) or physiological characteristics (like iris, palm print, finger print, and face) of an individual for recognition purpose [2, 3]. Palmprint is a dominant biometric trait because of its uniqueness and stability which leads to usage in various application domains [4]. In addition to this it has various advantages like stable line features, less expensive devices for acquisition, non-contact, larger palm area, and higher acceptance etc and contains good number of features like ridges, wrinkles, and dark palm lines [5, 6]. Because of these advantages, the palmprint based person recognition has gained more focus from researchers.

In a palmprint recognition system, the acquired image must be preprocessed due to presence of noise and to improve the image quality. The palmprint preprocessing takes several steps like image enhancement, edge detection, extrication of Region Of Interest (ROI) etc [7]. Then the ROI can be extracted by using various methods like bisector based approach [8], Tangent based approach [9] and finger based approach [10]. Then the features from palmprint can be extracted by using various methods such as line based features [7, 10, 11], subspace approach [7, 12], statistical approach [7, 10], and texture based approach [12, 13]. Various texture based methods like Gabor filters [13], Wavelets [14], and Fourier Transforms [15] etc can be employed to extract the texture features. Features extracted by using multiple algorithms have been

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fused at feature level fusion [16]. In this paper, texture features are extracted by applying 2D-Gabor filter, Log Gabor filter. These texture features are concatenated based on weighted feature level fusion. The integration of various feature vectors can be done at four levels: pixel level, feature level, confidence level, and decision level. Integration at confidence level ignores some correlation evidences between various feature vectors and pixel level carries noise present in images. Consolidation of information at decision level always considers limited amount of information. Due to these reasons feature level fusion is preferred [20]. In [17] the texture features from palmprint are extracted by applying 2D-Gabor and 2D Log-Gabor filters and then the feature vectors are constructed based on standard deviation of sub images of those Gabor textures. These feature vectors are concatenated to form the new feature vector as template. But the fusion at feature level leads to high dimensional data, which reduces the performance of recognition [12]. This curse of dimensionality problem is handled in proposed method by using Principal Component Analysis (PCA).

The remaining part of this paper is systematized as follows: Section 2 presents the proposed system. Preprocessing and extraction of ROI is presented in Section 3. A detailed study texture extraction from palmprint is presented in Section4. Section5 elevates how feature fusion has been done. Feature space reduction and matching specified in Section6. Experimental results and analysis is discussed in Section7. Section8 concludes this paper.
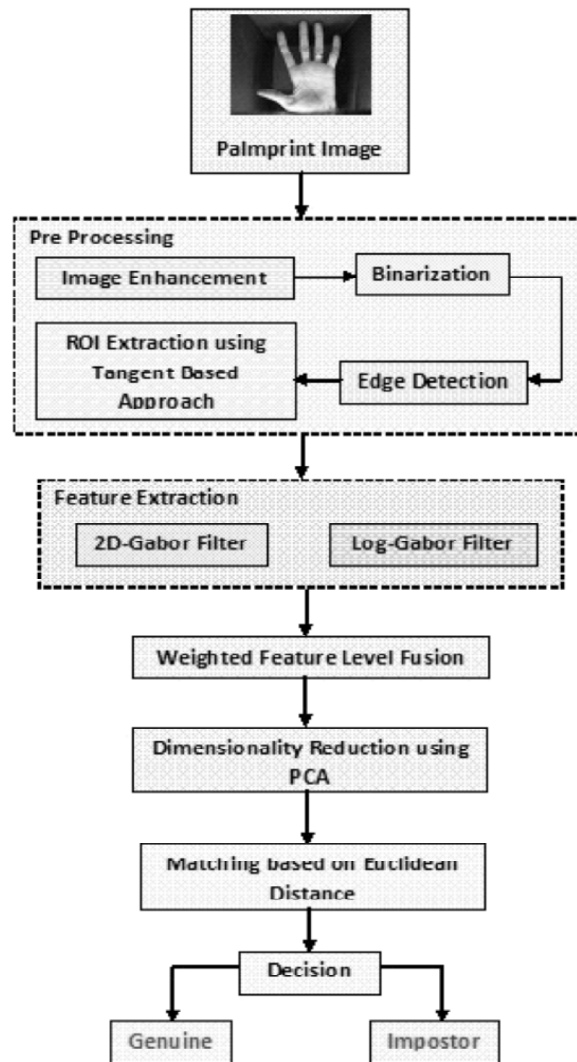

Figure 1: Proposed Methodology

II. PROPOSED ALGORITHM

The block diagram of the system is shown in Fig1. The silent features of the proposed system are:

- The key part of this paper is to examine the multi-algorithm based palmprint recognition using weighted feature level fusion and PCA.

- As unimodal biometric systems are affected by noise, spoofing attacks, and sample size, multimodal biometric system came to overcome these problems. One of the multimodal systems is multi-algorithm based system, in which multiple methods are applied to extract features from biometric source [12].

- Previously in palmprint recognition, extracted features are combined at various levels including feature level but not concentrated on dimensionality problem. In this, the palmprint biometric undergoes various stages like enhancement, edge detection and ROI extraction using tangent based approach. Then two feature sets are obtained by applying two different methods namely 2D-Gabor and Log-Gabor filters.

- In proposed method, the fused feature vector is obtained by applying weighted feature level fusion. Then feature space is reduced using PCA and the resultant vector is stored as a template.

- In Matching, the features extracted from claimed image matched against database using Euclidean distance at a user specific threshold to identify genuine or imposter.

III. PREPROCESSING AND ROI EXTRACTION

In order to remove the noise and disturbances in the image due to misconnections and isolated regions pre-processing is performed on the image before feature extraction. Initially, image is enhanced to increase the contrast between the features of palm. Low-pass filter has been applied as given in the equation 1.

$$H(p,q) = \begin{array}{l} 1,\ D(p,q) \le D_0 \\ 0,\ D(p,q) > D_0 \end{array} \qquad (1)$$

Where H is enhanced image, D is original image, D_0 is a user specific threshold value, and D (p, q) = $\sqrt{p^2 + q^2}$.

The binary image is obtained from enhanced image, to clearly identify the features. Then by applying sobel filter edges are detected with an assumption that the point at which discontinuity in intensity function or steep intensity gradient, where the edge occurs. Then the ROI of the image is extracted by using tangent based approach.

3.1. Tangent Based Approach

The reliability of any palm print recognition systems strongly relies on the precision obtained in the process of ROI segmentation from palm image. The middle part of the palm is extracted after the pre- processing based on various algorithms, which segments in various forms like circular, half elliptical or square regions for feature extraction. The square region is the simplest and extensively used. The blurred image is obtained by applying a low pass filter (LPF) on the cropped image. This blurred image suppresses the minor lines and also affects the major lines, which are prominent. ROI is extracted by following the steps:

1. Low pass filter has been applied to the given image.

2. The original gray scale image is converted into binary with grey value 0 or 1.

3. By employing the boundary tracing algorithm the border of the palm is obtained. Continue tracing by considering the coordinate at the bottom left of the palm and the tracing direction along palm

border in the counter clockwise direction until the starting point is met again. The pixels at border are gathered into a vector.

4. With starting coordinate values and the boundary values, Euclidean distance between those coordinates is calculated by using below equation:

$$DE(i) = ((X_{st} - X_b(i)) + (Y_{st} - Y_b(i))) \tag{2}$$

5. The valley points of the palm are obtained and the centroid of the valley points is calculated.

6. The angle of rotation is calculated by using the tan-1 function so that all the palms can be aligned in the same angle.

$$\theta = \tan^{-1}(Y_1 - Y_2)/(X_1 - X_2) \tag{3}$$

Where (X_1, Y_1) and (X_2, Y_2) are the coordinates of valley points.

7. A line is drawn along the valley points to compute length of the ROI based on the distance between the valley points.

The ROI of the palm image is obtained by cropping the sub image which contains rich features.

IV. TEXTURE EXTRACTION

In literature, Gabor filters have been thoroughly reviewed and applied to extract texture features from various biometric sources including palmprint [13, 17-18]. The texture information obtained from palm image by applying Gabor filter contains principle lines, ridges and wrinkles, etc.

4.1. Log-Gabor Filter

The Log-Gabor filter has been thoroughly studied by the researchers to the extraction of texture [17, 19]. The symmetry on the log frequency axis is the advantage of Log-Gabor filter. It is time/space and frequency invariant. The log axis is the best way for representing spatial frequency response of visual cortical neurons in medium and high-pass. The following steps are to be considered for extracting features using log Gabor filter:

1. The Fourier transform is applied to the images to define the scales and orientations of the filter.
2. The polar angle of the filter is calculated by using the tan inverse function.
3. The standard deviation of the Gaussian function is calculated.
4. For every orientation there will be filter angle. The filter angle for every orientation is calculated by using the tan inverse.
5. The angular filter component of the filter is calculated.
6. The log Gabor filter is applied by using the following formula:

$$G(\rho, \theta, p, k) = \exp\left(\frac{-1}{2}\left(\frac{\rho - \rho k}{\sigma p}\right)^2\right) + \exp\left(\frac{-1}{2}\left(\frac{\theta - \theta_{pk}}{\sigma \theta}\right)^2\right) \tag{4}$$

In which (ρ, θ) are the log-polar coordinates, k indexes the scale and p is the orientation, the pair $(\rho k, \theta_{pk})$ corresponds to the frequency center of the filters, and $(\sigma_\rho, \sigma_\theta)$ the angular and radial bandwidths.

4.2. 2D-Gabor Filter-

Gabor filter bank, Gabor wavelets and Gabor transform are extensively used in pattern recognition. This function gives exact location of time-frequency and also provides sturdiness against unstable contrast and

brightness of images. In addition, this filter can model receptive fields of a simple cell in the primary visual cortex [13]. Based on these properties the following Gabor filter bank have been applied to palmprint texture extraction.

$$g(p,q;\theta,\varphi,\sigma,\gamma,\lambda) = exp\left(\frac{p^2 + \gamma^2 q^2}{2\sigma^2}\right) + exp\left(i\left(2\pi\frac{p}{\lambda} + \varphi\right)\right) \tag{5}$$

Where

$$\mathrm{p} = p\cos\theta + q\sin\theta \tag{6}$$

$$q = -p\sin\theta + q\cos\theta \tag{7}$$

In this equation, λ signifies the sinusoidal factor wavelength, θ gives the orientation of the normal to parallel stripes of a Gabor function, φ is the phase offset, σ is the standard deviation of the Gaussian envelope and γ is the spatial aspect ratio and specifies the ellipticity of the support of the Gabor function.

V. FEATURE LEVEL FUSION

As the extracted feature set contains richer information about the raw image than matching score or decision, anticipating better performance and results of the recognition system by the concatenation of feature sets at this level. The feature sets obtained from various modalities or from same modality by using different algorithms may be incompatible. Then normalize the feature sets into same domain before fusion. Integration can be performed in various ways like simple concatenation, sum rule, average rule, and weighted average rule. It results in a high dimensional feature space which can be handled by dimensionality reduction.

The texture features of a palmprint image j obtained from 2D-Gabor filter is $F_{(j, G)}$ and from Log Gabor is $F_{(j, L)}$. These feature vectors are then integrated based on weighted average rule. Here different set of weights are assigned and finally selected the one which yields the best result.

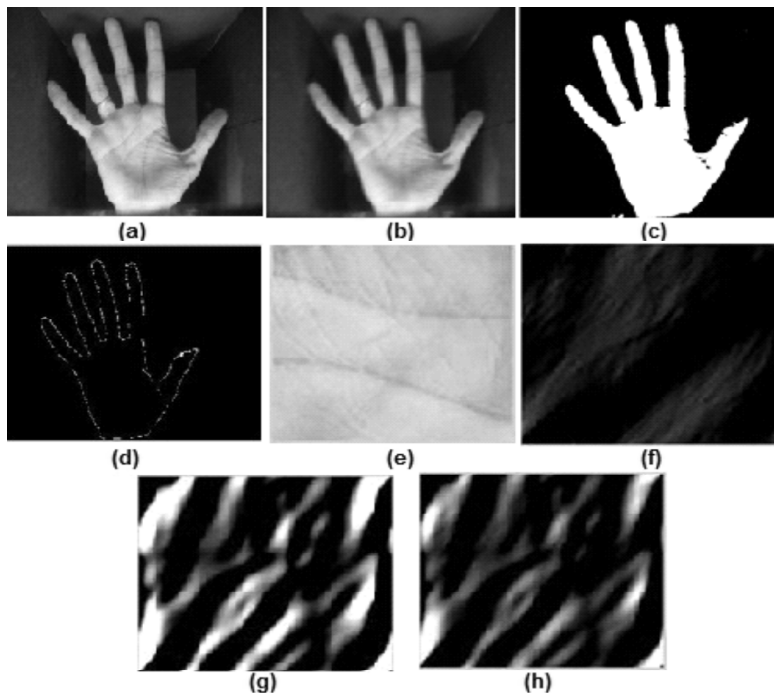$$F_{(j, fused)} = \frac{(w_1 * F_{(j,G)}) + (w_2 * F_{(j,L)})}{2} \tag{8}$$

Figure 2: (a) Original Input Image (b) Image after Enhancement (c) Image after Binarization (d) Image after Edge Detection (e) ROI (f) 2D-Gabor features (g) Log-Gabor features (h) Fused features

Where $F_{(j, fused)}$ is a resultant feature vector obtained after weighted fusion, w_1 is the weight assigned to the feature vector extracted from 2D-Gabor filter and w_2 is weighed assigned for Log-Gabor filter. As the rich texture features are obtained from 2D-Gabor when compared with Log-Gabor, the experiments are done with weights w_1 as 0.6 and w_2 as 0.4. These values are selected by considering various combinations of values as weights and picked up where maximum accuracy is reached.

VI. PCA & MATCHING

As the resultant feature vector obtained from feature level fusion is high dimension vector [12], to decrease the dimension of combined feature vector, Principal Component Analysis (PCA) is applied to F_{fused}. PCA transforms correlated variables into uncorrelated variables known as principal components and also preserves the global structure and decreases dimension without information loss.

By using Euclidean distance, the distance between the reduced enrolled feature vector and the claimed feature vector is calculated. This distance is compared against a user specific threshold to decide the genuine or imposter.

VII. RESULTS & ANALYSIS

The experiments are carried out on IIT Delhi plamprint database in which 100 objects and for each object 5 samples, total 500 samples are taken. The proposed systems performance is determined by using the measures, False Acceptance Rate (FAR), False Rejection Rate (FRR), and Accuracy. FAR is the rate at which the unauthorized user is accepted as Genuine. FRR is the rate at which the authorized person is rejected as imposter. Palmprint recognition based on fusion gives tremendous increase in accuracy when compared to recognition by using only either 2D-Gabor features or Log-Gabor features.

The experiments are performed at FRR value 0.025 and at various thresholds, obtained the FAR values. Based on these FAR and FRR values the accuracy of the recognition system has been calculated. These results are shown in Table1 for database of different number of objects like 20,40,60,80, and 100. In all these it was clearly gives increase in recognition accuracy for proposed method and obtained maximum accuracy of 98.5% at FAR value 0.005 which is shown in the Table 1.

Table 1
FAR values at different Threshold value and FRR of 0.025 for database of various sizes

Threshold	FAR for 20 Objects	FAR for 40 Objects	FAR for 60 Objects	FAR for 80 Objects	FAR for 100 Objects
6	1	1	1	0.9813	0.98
7	0.975	1	0.975	0.825	0.825
7.5	0.975	0.975	0.9417	0.6938	0.66
7.8	0.975	0.9625	0.9083	0.5688	0.495
7.9	0.975	0.9625	0.8917	0.5	0.405
8	0.975	0.9625	0.875	0.4355	0.335
8.1	0.975	0.95	0.8417	0.3375	0.245
8.2	0.975	0.95	0.825	0.2375	0.12
8.25	0.95	0.925	0.7917	0.1438	0.025
8.27	0.95	0.925	0.7917	0.125	0.005

ROC curve demonstrates the measured accuracy of proposed palmprint recognition system. ROC curves are generated by varying the user specific threshold on the categorization image and an optimal value of the

threshold is selected at the minimum FAR. The ROC curves in Fig3, Fig4, Fig5, Fig6, and Fig7 depicts the correlation between FAR and thresholds at FRR of 0.025 for multi-algorithm based palmprint recognition system.

This method not only increases the system accuracy, also the application of PCA reduces the size of feature set obtained after concatenation to 92%. This greatly reduces the storage space required for template at the same time the processing time required for entire method.
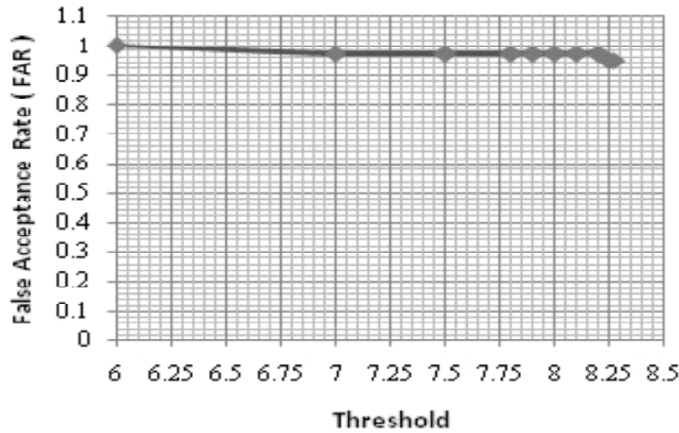

Figure 3: ROC curve between Threshold and FAR for database of 20 Objects
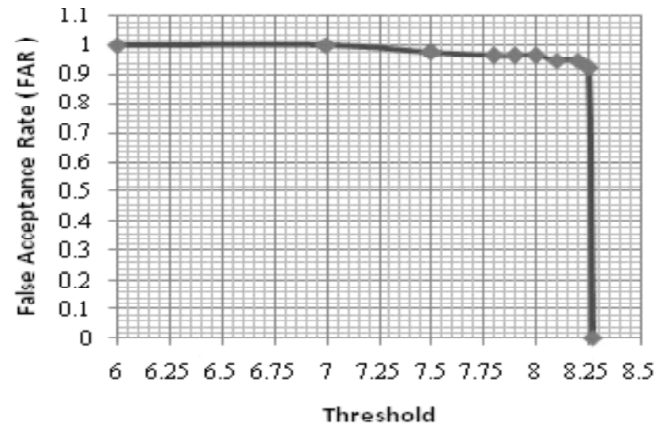
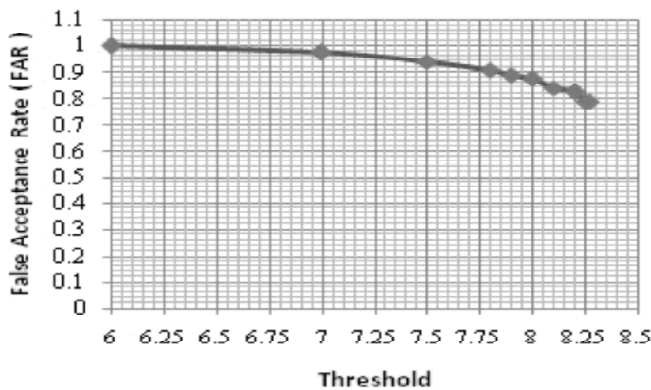**Figure 4: ROC curve between Threshold and FAR for database of 40 Objects**

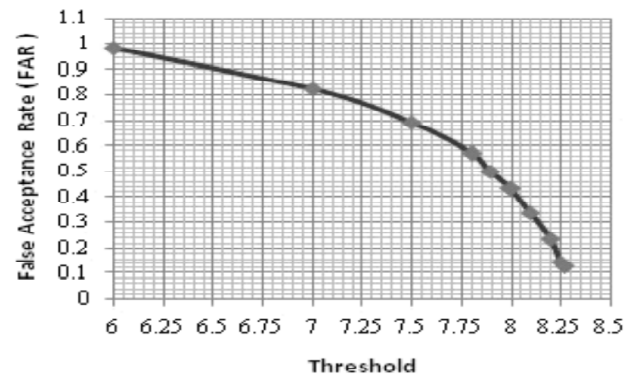**Figure 5: ROC curve between Threshold and FAR for database of 60 Objects**

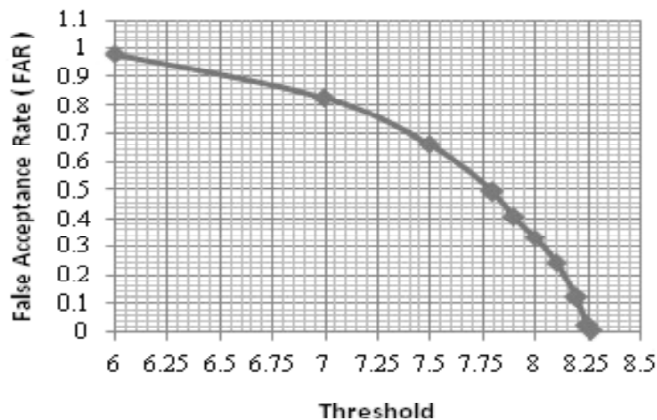**Figure 6: ROC curve between Threshold and FAR for database of 80 Objects**

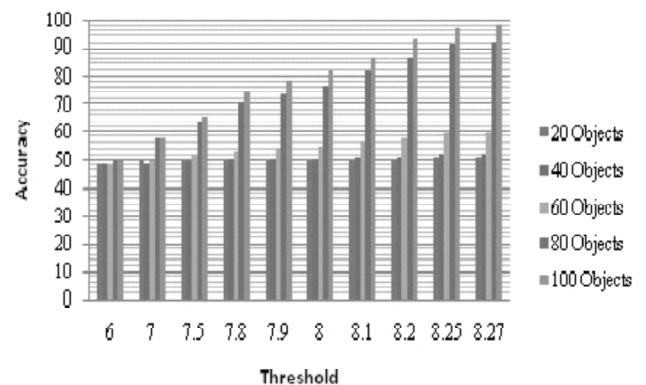**Figure 7: ROC curve between Threshold and FAR for database of 100 Objects**

Figure 8: Comparison of Accuracy at various sizes of database

VIII.CONCLUSION

Multi-algorithm weighted feature level fusion based palmprint recognition was investigated and presented the results. These experiments are carried out by considering the texture features extracted by using 2D-Gabor and Log-Gabor filters and applied reduction technique PCA after fusion. In database of 500 palmprint images from 100 distinguished users, the reduction based fusion method achieves high genuine rate 98.5% and low false acceptance rate 0.005% when compared to the remaining palmprint recognition methods. On i3 processor based PC, the execution time for the entire process from preprocessing to matching is nearly less than 1second. In future, our concentration will be on further improvement in accuracy with reduction in storage space and processing time.

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