Palmprint verification based on textural features by using Gabor filters based GLCM and wavelet

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***Abstract*—The palmprint is one of the most reliable physiological characteristics Among different approaches that exist in biometric. palmprint due to having high acceptability, stability and low cost of implementation has drawn attention from researchers. In this paper, we considered the palmprint as a texture and applied two types of feature extraction methods, namely Gabor filters based Gray-Level Co-occurrence Matrix and Discrete Wavelet Transform. In total 350 features that are extracted by these approaches, fifty superior features selected by the forward feature selection algorithm. Features are classified with new method of using reference features in order to achieve higher resolution and by using K-Nearest Neighbor and Fuzzy K-Nearest Neighbor classifiers. In CASIA testing database of 5,502 palmprint samples from 312 palms, we achieved Equal Error Rate of 1.25% ± 0.56 and Accuracy of 98.75% ±0.56 with 60% train by K-Nearest Neighbor classifier.**

Keywords-Palmprint; Verification; Gabor filters; Wavelet; Gray-level co-occurrence matrix; Classifier

I. INTRODUCTION

Nowadays biometric systems play an important role in our lives. Since as other technologies are developed the duty of biometric systems are stronger in order to maintain the security of citizens. Biometric could be used as identification systems that seek to identify an unknown person or as verification systems that authenticates an individual by comparing one specific pattern stored in the database. In general, recognition methods in biometric systems categories in three classes of physiological, behavioral, and chemical. Among that physiological approaches due to use of inherent characteristics are more reliable. Seven factor affect on a physiological characteristic accepted as a biometric feature: universality, uniqueness, permanence, collectability, performance, acceptability, and circumvention [1].

One of the physiological characteristics that has drawn attention of researchers is palmprint. Palmprint due to having various features such as principal lines, wrinkles, and edges with high stability and acceptance is considered as one of the best physiological characteristics in the area. Principal lines that in palmist terminology are called life-line, head-line, and heart-line, are thick lines that exist almost in the all palmprint images. Wrinkles are thinner than principal lines, irregular and expand in all over the palm. Edges are the same features that have been used in fingerprint and can be extracted from high resolution images. There are three types of line-based, subspace-based and texture-based feature extraction in palmprint verification systems. Since principal lines may be similar in different person using both wrinkles and principal lines together is useful. Therefore, texture-based approach is used in order to feature extraction.

In general, there are four main steps in palmprint verification systems: 1) data acquisition 2) preprocessing 3) feature extraction 4) classification. We are testing our proposed method on Chinese Academy of Sciences Institute of Automation (CASIA) database [2]. In the preprocessing step region of interest extracted as square shape. Features are extracted based on Gabor filters, gray-level co-occurrence matrix (GLCM) and discrete wavelet transform (DWT) and also two classifiers of k-Nearest Neighbors (KNN) and Fuzzy k-Nearest Neighbor (FKNN) are used in order to classify. The rest of the paper is organized as follows: A review of previous works are given in section 2, Preprocessing is mentioned in section 3, feature extraction is characterized in section 4, results are shown in section 5 and the conclusion is described in section 6.

II. RELATED WORK

Guo et al. presents a palmprint recognition approach using the local information from a single image every person. Among the five methods of statistics feature, Fourier transform, DCT transform, Gabor transform and local binary pattern (LBP) they were used for feature extraction, the recognition rate of the LBP method with recognition rate of 91% is the best [3].

Edward et al. used Three different feature extraction methods, namely, Discrete Cosine Transform (DCT) energy feature, Wavelet Transform (WT) energy feature and SobelCode. Two types of feature matching, namely similarity measurement and neural network also are used in this work. DCT energy features and wavelet energy features are matched using Euclidean Distance while the SobelCode is matched by Hamming Distance. An accuracy of 98 percent obtained using the WT energy features method [4].

Sang et al. are used contactless method, the sizes and orientations of the ROIs are different. According to the angle relation between the new coordinate system and the original coordinate, the image is rotated. After that, the size of the

ROIs are resized a standard image to 128 pixels × 128 pixels. the local binary pattern (LBP) is applied to the palmprint in order to extract the palmprint features. Finally, chi square statistic is used for classification. the equal error rate of 3.76% and correct recognition rate of 97.01% reported in the paper [5].

Gayathri and Ramamorthy are applied Gabor wavelet to extract multiple features available on the palmprint, by employing a feature level fusion and classified using nearest neighbour approach. The feature extraction that is obtained using wavelet entropy technique. The wavelet entropy is used for feature extraction of image. The features are: Energy, Contrast, Homogeneity and Correlation. in this paper obtained recognition accuracy for Gabor real part accuracy as 98.4 percentages with false acceptance rate 1.6% and false rejection rate 0.8%.Gabor imaginary part accuracy as 97.63 percentages with false acceptance rate 2.4% and false rejection rate 0.8% [6].

Kumar and Parekh proposed a technique to model and compare palmprint images involving Eigenvector decomposition. palmprint images are mapped to Eigen-space and a robust code signature is generated from different camera snapshots of the same palm to incorporate tonal and lighting variations. Salient features of the proposed technique include a low dimensional feature representation of the palmprint texture, low computational overheads and high recognition accuracies of over 98% [7].

III. PREPROCESSING

Image preprocessing is the name for operations on images at the lowest level of abstraction that the aim is an improvement of the image data that suppress undesired distortions or enhances some image features important for further processing[8]. In the preprocessing several steps, like noise reduction, alignment, extract a region of interest (ROI) are done on images and prepare them for feature extraction.

The CASIA palmprint image database contains 5502 palmprint images captured from 312 subjects. It collects palmprint images from both left and right palms. All palmprint images are 8 bit gray-level JPEG files. The device supplies an evenly distributed illumination and captures palmprint images using a CMOS camera fixed on the top of the device. The eight typical palmprint images in the database are shown in Fig. 1.

Seven main steps are used in order to extract ROI. Figure 2 gives a block diagram to describe the relationship between the seven steps.

Fig. 3 is indicated the overall steps that are done in preprocessing. At first median filter with size of 3x3 is used for removing probability noise in the image. For binarization, selection good threshold plays an important role in the final result hence by the help of Otsu method and trial and error, image converts to binary that is shown in Fig. 3(b). Finding the web-points constitute next step.

For this purpose the algorithm that mention in [9] is employed. The proposed method has two advantages. The first is that it can reduce the movement of the ROI to an acceptable range. The second is that the range of palm rotation and shift while acquiring palmprint images can be reduced. First inner boundary tracing algorithm is used to find the palm border. The border pixels can be collected into a vector called Border Pixel Vector (BPV). Then for each pixel of BPV Euclidean distance from the centroid pixel (C_m) of the image is calculated.

$$D_E(\mathrm{i})=\sqrt{(X_{cm}-X_b(i))^2+(Y_{cm}-Y_b(i))^2} \qquad (1)$$

Where (X_{wm}, Y_{wm}) is the coordinate of the centroid point C_m, $(X_b(i), Y_b(i))$ is the coordinate of the ith border pixel, and $D_E(\mathrm{i})$ is the Euclidean distance between the ith border pixel and the centroid point C_m.

A distance distribution diagram is indicated in Fig. 3(c) which has four finger-webs (local minimums). Experimenting on a wide variety of palmprint images are shown that the four local minimum locations in the distance distribution diagram are the same as finger-web locations. The first three points that are denoted in Fig. 3(d) are the points that we need for coordinate construction. The tangent between web-points FW1 and FW2 is calculated and by using that, images are normalized. If images are normalized before feature extraction, the location of the features would be consistent among different images in the data set. A line is drawn between two web-points of 1 and 2 which constitute Y-axis. X-axis by drawing a perpendicular line to midpoint of the Y-axis is given. Initial ROI is shown in Fig. 3(e). Then with specific offset initial ROI is moved forward. The coordinate system and ROI are displayed in Fig. 3(f) and Fig. 3(g)

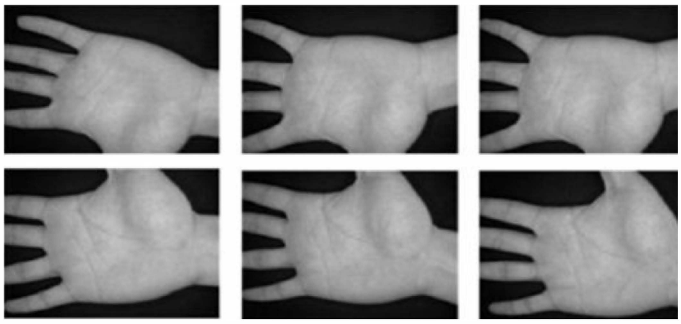

Figure 1. Eight typical palmprint images in database

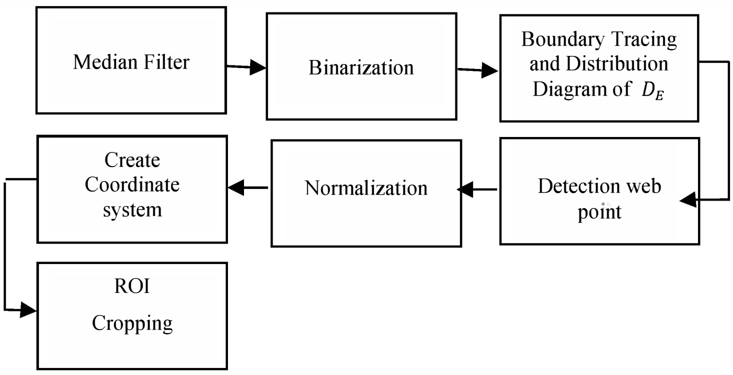

Figure 2. Seven main steps for preprocessing

respectively. The size of original palmprint images in the CASIA palmprint database under study is 480 × 640 pixels, while the size of is extracted ROI based on the coordinate system is 150×150 pixels. Fig. 4 is shown the ROI samples of 6 users.

IV. FEATURE EXTRACTION

The problem of extracting features from given data is one of critical importance for the successful in palmprint verification system. Among different approaches that are exist in the palmprint feature extraction; texture-based approach because of using both lines and wrinkles is selected. Extraction of texture features should efficiently embody information about the textural characteristics of the image. In order to extract texture features from ROI, various methods such as Gabor filters, DWT, GLCM, discrete cosine transform (DCT), local binary pattern (LBP) exist.

In this paper two different types of feature extraction are used namely Gabor filters based GLCM and Wavelet transform. Features are combined at feature level using specific fusion algorithm we combine these feature vectors to form a composite feature vector. This feature vector is then used for classification process.

A. Gabor Filters based GLCM

Using Gabor filters for extraction texture features are effective but simultaneous use of Gabor filter and GLCM can be more effective. In this paper is used new method of feature extraction by consideration Gabor filters and GLCM that details of the method are discussed in the following contexts.

The Gabor filters directly used from gray level images. In the spatial domain, a two-dimensional Gabor filter is a Gaussian kernel function modulated by a complex sinusoidal plane wave, defined as [10]:

$$G(x,y) = \frac{f^2}{\pi\gamma\eta} exp\,(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}) exp\,(j2\pi f x' + \varphi) \quad (2)$$

$$y' = xcos\theta + ysin\theta$$

$$x' = -xsin\theta + ycos\theta$$

Where f is the frequency of the sinusoid, θ represents the orientation of the normal to the 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 which specifies the ellipticity of the support of the Gabor function. We employ thirty Gabor filters in five scales and six orientations that are shown in Fig. 5 after convolve to the image.

The GLCM is one of the most widely used approaches to extract features of textures. The co-occurrence matrix measures the appearance probability of the pairs of the values of the pixels situated at some distance in the image. GLCM of the image create based on correlation and amounts of the image pixels. In this method by using GLCM is tried to find the relationship between pixels of the image that create by convolution of the Gabor filters to the ROI. Features that are extracted with this approach respectively are: contrast, correlation, energy, homogeneity, inverse difference moment (IDM), mean and standard deviation. Calculation methods of each one are mentioned in follow. In total 210 features are extracted by this approach.

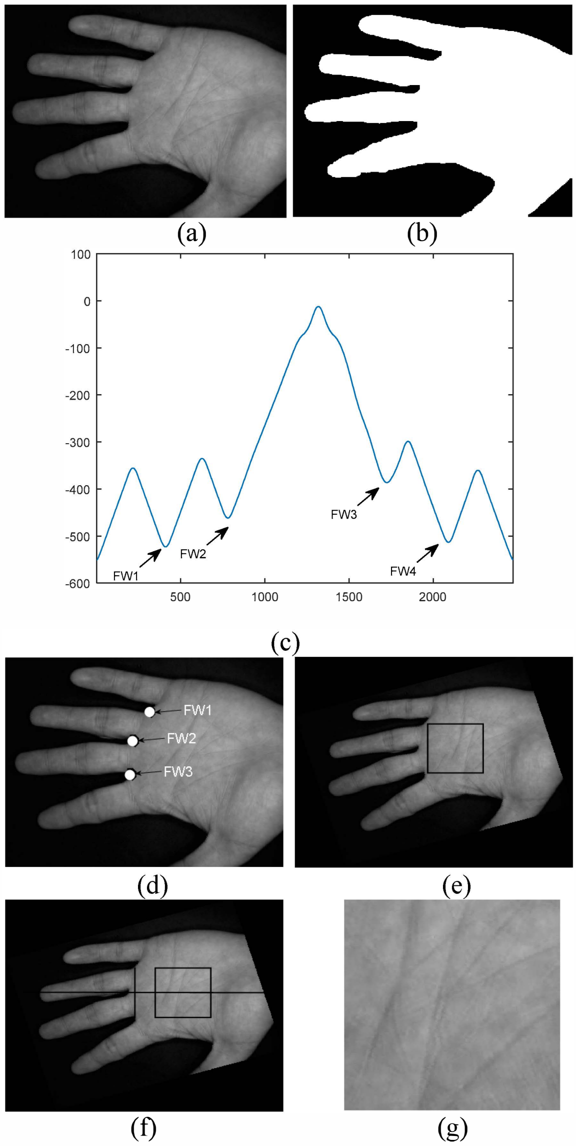

Figure 3. Overall palmprint ROI extraction algorithm for palm print image. (a) image after apply median filter (b) binary image (c) boundary tracking to detect web points (d) three main webpoints (e) normalization and initial ROI (f) palmprint coordinate system and ROI (f) ROI cropping.

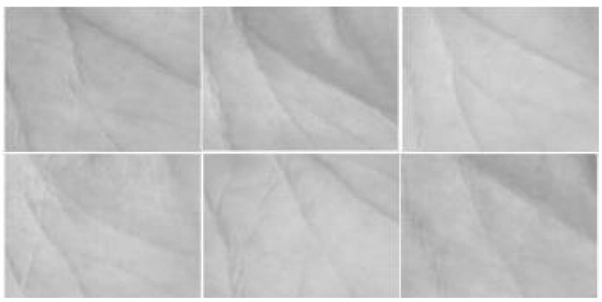

Figure 4. Palmprint image of eight subject.

$$\text{Contrast}=\sum_{n=0}^{G-1} n^2\left\{\sum_{i=1}^{G}\sum_{j=1}^{G} P(i,j)\right\},\ |i-j|=n \quad (3)$$

$$\text{Correlation}=\sum_{i=0}^{G-1}\sum_{j=1}^{G-1}\frac{\{ij\}P(i,j)-\{\mu_x\mu_y\}}{\sigma_x\sigma_y} \quad (4)$$

$$\text{Entropy}=-\sum_{i=0}^{G-1}\sum_{j=1}^{G-1} P(i,j)\log(P(i,j)) \quad (5)$$

$$\text{IDM}=\sum_{i=0}^{G-1}\sum_{j=1}^{G-1}\frac{1}{1+(i-j)^2}P(i,j) \quad (6)$$

$$\text{Homogeneity}=\sum_{i=0}^{G-1}\sum_{j=1}^{G-1}\frac{1}{1+|i-j|}P(i,j) \quad (7)$$

$$\text{Standard deviation}=\sqrt{\frac{1}{N-1}\sum_{i=0}^{G-1}\sum_{j=0}^{G-1}(p(i,j)-\mu)^2} \quad (8)$$

Where G is the number of gray levels used, μ is the mean value of P. μ_x, μ_y, σ_x, σ_y are the means and standard deviations of P_x and P_y.

B. Discrete Wavelet Transform

Discrete wavelet transform widely is used in various application of image processing such as compression, denoising and feature extraction. Also using wavelet transform in order to texture analysis is effectiveness.

Discrete Wavelet Transform (DWT) is a more general way to represent and analyze multi resolution images. The resulting wavelet transform is a representation of the image at different scales. We have used Haar at level 3 of the decomposition. The features that are used in this section are the means of all rows of approximation matrix and standard deviation of all rows of approximation, horizontal, vertical and diagonal matrixes. In total 140 features are extracted by this approach.

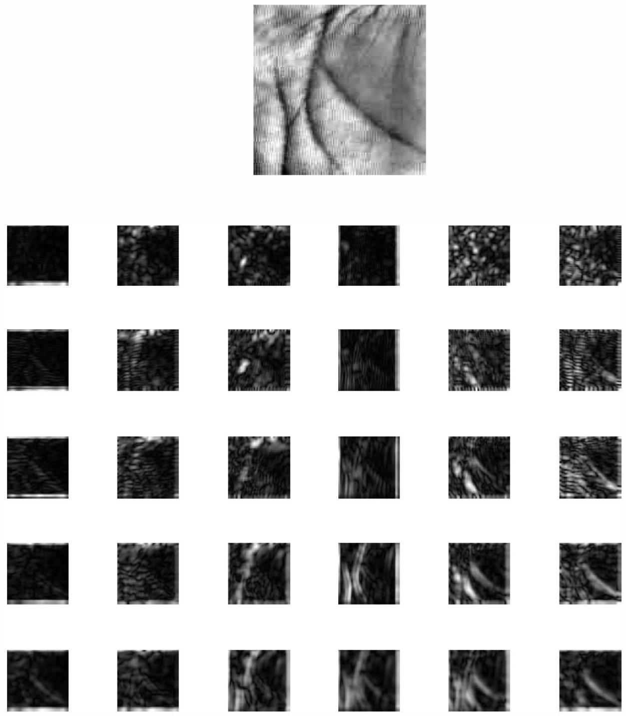

Figure 5. Magnitudes of Gabor filters with 5 scales and 6 orienttion after convolve to the ROI.

V. RESULTS

In a comparison process, the validity of the test image is evaluated by matching its features against reference information. In particular, the selection of reference information for an image verification process can be made following two different approaches. The first approach is based on the use of a single template of genuine image, for each person. The second approach is based on using a set of genuine image for reference.

Features have been used in classification with two classifiers: KNN and FKNN. KNN is one of the famous methods that are existed in pattern recognition. but when the density of training data is uneven it may decrease the precision of classification if someone considers the sequence of first k nearest neighbors but does not consider the differences of distances [11]. The FKNN assigns class membership to a sample vector rather than assigning the vector to a particular class [12].

Fifty features have been selected based on Forward Feature Selection (FSS) algorithm from 350 extracted features. Fig. 6 and Fig. 7 indicate that by ten features best results for both classifiers are obtained. For every person we are considered twenty impostors randomly. Three samples are selected as the reference patterns among eight genuine samples that are exist for each one. The remaining genuine images are used for verification testing and evaluation. Features of each subject have been compared with reference pattern features and a distance vector has been computed [13]. By computing minimum, maximum and mean of every distance vector, three dummy features have been generated. By consideration minimum distance (d_{min}) between three references and impostor samples for feature (i) every distance is normalized by (2).

$$d_{Normailized}=e^{-k.d_{min}/D_{max}} \quad (9)$$

Where k = 3 is the normalization factor that is obtained from trial and error and D_{max} is the maximum distance of all the reference and impostor patterns.

The performance of the classification was evaluated with EER. In order to results become fixed, mean of the EER is obtained after 10 runs. The number of trains from 10% to 90% with 10% step is increased. The results are shown in Fig. 6, Fig. 7 and also in Table 1 and Table 2 based on different classification. Table 1 and Table 2 are demonstrated EER of the KNN and FKNN classifiers for different train percents and superior features respectively. Also Table 4 demonstrate total mean of EER on the all percents after 10 iterations. In Table 3 proposed method is compared with early related works that are done in this area.

The results are shown K-NN with 60% training has the best result with EER of 1.25% $\pm$0.56. By using (10) Accuracy (Acc), is obtained and equal to 98.75$\pm$0.56%.

$$Acc = 100 - EER(\%) \quad (10)$$

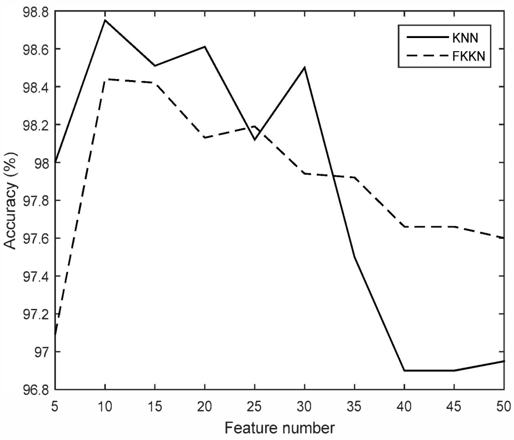

Figure 6. Performance of the proposed method (Accuracy) with 60% training

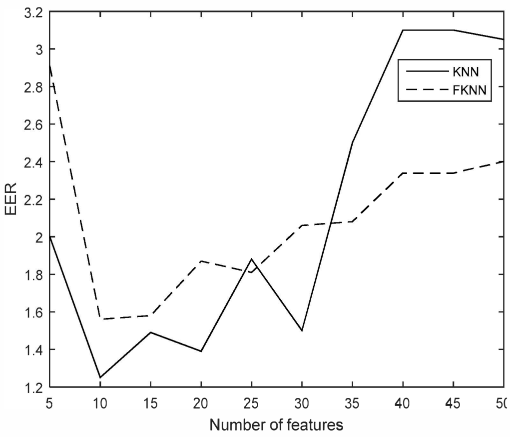

Figure 7. Performance of the proposed method (EER) with 60% training

TABLE I. MEAN OF EER(%) AFTER 10 ITERATION USING KNN CLASSIFICATION WITH DIFFERENT TRAINING RATE

Number of features / *Train*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*50*
10%	3.85	3.07	4.07	6.06	7.06	7.03	7.58	7.36	7.36	7.27
20%	2.98	2.20	3.34	4.49	6.21	6.04	6.32	6.91	6.91	7.13
30%	2.37	1.86	1.92	2.72	5.27	5.29	5.87	6.10	6.10	6.49
40%	2.40	1.89	1.76	1.79	4.82	4.48	6.06	6.16	6.16	6.30
50%	1.77	1.82	1.57	1.78	2.07	3.21	4.04	5.68	5.68	5.69
60%	2.00	**1.25**	1.49	1.39	1.88	1.50	2.50	3.10	3.10	3.05
70%	1.80	1.99	1.74	1.66	2.66	1.77	2.54	3.46	3.46	3.28
80%	1.76	2.06	1.86	1.73	2.78	2.34	2.65	3.82	3.82	3.91
90%	2.46	2.13	1.94	1.89	2.85	2.41	2.39	4.09	4.09	5.55

TABLE II. MEAN OF EER(%) AFTER 10 ITERATION USING FKNN CLASSIFICATION WITH DIFFERENT TRAINING RATE

Number of features / *Train*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*50*
10%	4.33	2.64	2.68	2.95	3.65	3.61	4.21	3.97	3.97	4.35
20%	3.40	2.13	2.31	2.39	2.73	2.99	3.21	3.49	3.49	3.72
30%	3.13	1.85	1.91	2.02	2.48	2.50	2.74	2.98	2.98	3.03
40%	2.95	1.63	1.76	1.79	2.36	2.37	2.56	2.68	2.68	2.83
50%	2.79	1.60	1.57	1.98	2.07	2.15	2.30	2.54	2.54	2.55
60%	2.91	1.56	1.58	1.87	1.81	2.06	2.08	2.34	2.34	2.40
70%	2.59	1.59	1.65	1.96	1.92	2.17	2.20	2.31	2.31	2.52
80%	2.63	1.62	1.71	2.01	1.98	2.28	2.45	2.46	2.46	2.66
90%	2.71	1.83	1.89	2.10	2.05	2.50	2.60	2.63	2.65	2.71

TABLE III. COMPARISON DIFFERENT METHODS

Ref	*features*	*Classifier*	*Result*
Saini and Sinha, 2011 [14]	Gabor filters	Hamming distance	EER(%) = 10.3
Lu et al 2013 [15]	feature point number	SVM	CCR(%) = 98.3
Bong et al 2011 [16]	Lines of the palm with Roberts	AND function	EER(%) = 15
Raghavendra et all 2015 [17]	B-BSIF	sparse representation classifier	EER(%) = 4.06
Arunkumar et al 2016 [18]	Improved Histogram of Oriented Lines	Cosine distance	RR(%) = 97
Raghavendra et all 2014 [19]	Log-Gabor transform	Sparse Representation Classifier	EER(%) = 7.67
Proposed	Gabor, GLCM and wavelet	KNN	EER(%) = 1.25 ACC(%) = 98.7

TABLE IV. TOTAL MEAN OF EER AFTER 10 ITERATION FOR ALL PERCENTS OF TRAIN BY USING TWO CLASSIFICATIONS

Features / *Classifier*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*50*
KNN	2.3	2.0	2.2	2.6	3.9	3.8	4.4	5.2	5.2	5.4
FKNN	3.0	1.8	1.9	2.1	2.3	2.5	2.7	2.8	2.8	2.3

VI. CONCOLUTION

In this paper verification algorithm based texture feature was suggested. The experimental results demonstrate combination of palmprint features that are extracted by two methods that mention in section 3 have better results rather than using them separately. A preprocessing algorithm extracts the central area from a palmprint image size 150 x150 for feature extraction. We used new method of Gabor filters based GLCM and DWT for extraction texture features, by using FFS 50 superior features selected and the results show using 10 superior features for both knn and fknn had best result. Also for classification used new method that led to using one classifier instead of using N classifier for N person. Using this verifier, we can obtain 0.98.75%$\pm$0.56 accuracy with 60% train. In comparison with related works that are mentioned in Table 1 proposed method has less EER. This mechanism is very suitable and comfortable for all users. In future we will concentrate on reduce errors by combining palmprint with other biometrics systems.

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