Phase Congruency Corner Detection as Biometric Feature

Vinod Kumar D[1], Dr. Nagappan A[2], Jyoti Malik[3]

[1, 3] Department of Computer Science and Engineering, V.M.K.V. Engineering College,
[2] Principal, V.M.K.V. Engineering College,
Vinayaka Missions Research Foundation Deemed University
Salem, Tamilnadu, India

Abstract: Palmprint is one of the most reliable physiological biometric due to its unique and permanent features like geometry features, principal line features, wrinkles, ridges, delta point features, texture features and points. Here, Phase Congruency Corner Detector method is proposed as a corner detection technique to extract palmprint features in the form of corners. The palmprint features extracted are binarized and then matched using Hamming distance similarity measurement with sliding window method. By using hamming distance method for corner matching, the comparison time is non-dependent on the number of corners detected. So, the comparison (matching) time will be constant irrespective of the number of corners. Experiments were developed on a database of 600 images from 100 individuals, with five image samples per individual for training and one image sample per individual for testing. The proposed approach is applied on PolyU database and the experimental results demonstrate that the proposed approach has good discriminating effect.

Keywords: Palmprint, Feature extraction, Phase congruency, Hamming distance.

Introduction: In recent years, among several biometric recognition methods palmprint has emerged as the most effective method due to its stable and unique features [1-5]. Palmprint authentication has been used in several applications like security and access control [6-10].

Palmprint consists of five types of features. They are geometry features, line features, point features, texture features, statistical features and points. Several palmprint authentication techniques are available in the literature. Han et al. [18] proposed the peg less and inkless usage of palmprint image. Sobel, Wavelet transform, Fourier transform [5, 9] are some of the techniques used for palmprint authentication. Kong et al. [19] proposed 2D Gabor filters to extract texture information from the palmprint image and matching the images using Hamming distance similarity measurement.

In this paper, Phase Congruency Corner Detector is proposed to detect the corners. The Phase Congruency Corner Detector uses the principal moments of the phase congruency information to determine corner information. The corner information image is binarized to form the feature vectors. Hamming distance similarity measurement method is used as a feature matching method.

The originality of the concept is explored on two aspects, first, the comparison time does not depend on number of corners, second, the corner information image is binarized and hamming distance method is applied which is also applicable on edge matching method.

The following section of the paper is organized as follows: Section 2 describes the basic of palmprint authentication system. Section 3 describes palm image pre-processing. In section 4 feature extraction by Phase Congruency Corner Detection is proposed. Section 5 presents feature matching by Hamming distance similarity measurement method. Section 6 explains reference threshold calculation. The experimental results are presented in Section 7, while section 8 concludes the paper.

2. Palmprint Authentication System

In this paper, the palmprint authentication system is divided in following two subsystems:

(a) Pre- Authentication System

(b) Authentication System

In Pre-authentication system, a database of Palmprint features is prepared. In addition, Reference threshold value is also identified and stored in database.

In Authentication system, the authenticity of a person is identified with the help of Reference threshold value.

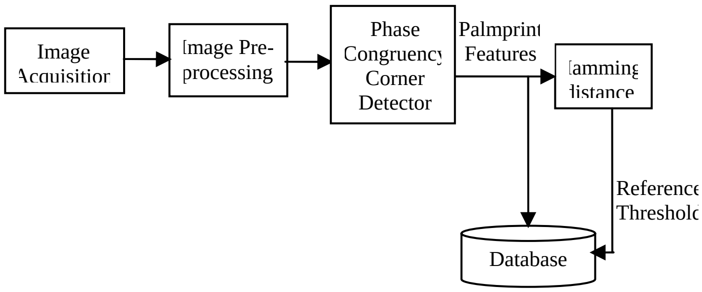


Figure 1: Palmprint Pre-Authentication system

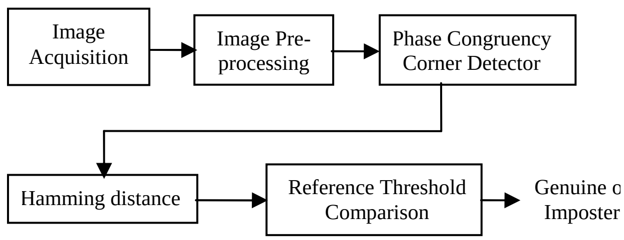


Figure 2: Palmprint Authentication System

3. Palm Image Pre-Processing:

The purpose of image pre-processing is to enhance the image and to get ROI (Region Of Interest) for feature extraction. The valley points between little finger, ring finger (V1) and index finger, centre finger (V3) are used as reference points to determine ROI. The basic steps in pre-processing stage are shown in Fig. 3.

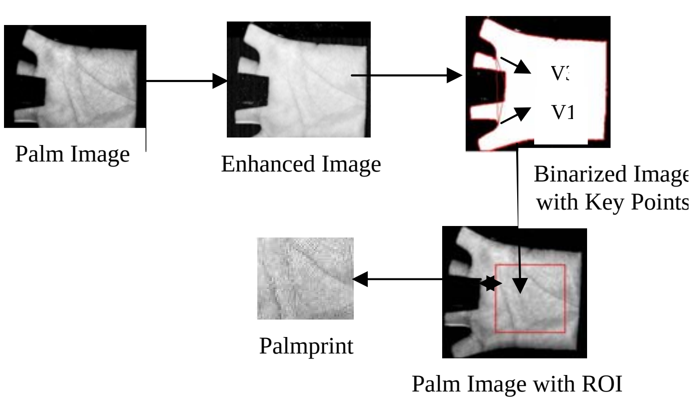


Figure.3. Steps of Image Pre-processing

4. Feature Extraction by Phase Congruency Corner Detector

In this paper, corner features are extracted from the palmprint image using phase congruency method. The quality of phase congruency feature extraction method is that it is invariant to changes in image contrast and do not depend on intensity gradients. Corner information is extracted using the principal moments of the phase congruency information.

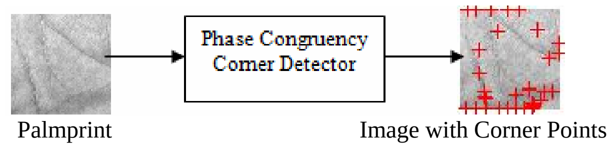


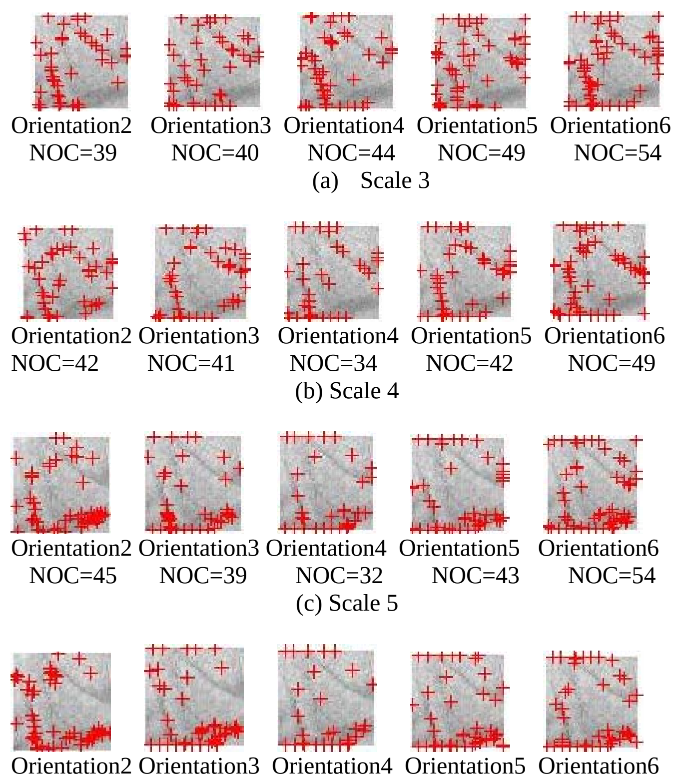
Figure 4: Corner detection by Phase Congruency Corner detector on palmprint image, '+' defines the corners detected

The phase congruency model finds out the points in the palmprint where log-Gabor filter response over various scales and orientations is maximal in phase. The feature vector FV is constructed by computing the minimum principal moment at various scales and orientations. The feature vector will consist of corners points.

FV = Corner points (1)

The corner information is binarized so that Hamming distance method can be applied.

The corner information and binarized corner information images are displayed in Fig. 5 and Fig.6.



NOC=49 NOC=41 NOC=29 NOC=41 NOC=43

(d) Scale 6

Figure 5: Phase Congruency Corner information, '+' defines the corners detected, NOC defines number of corners.

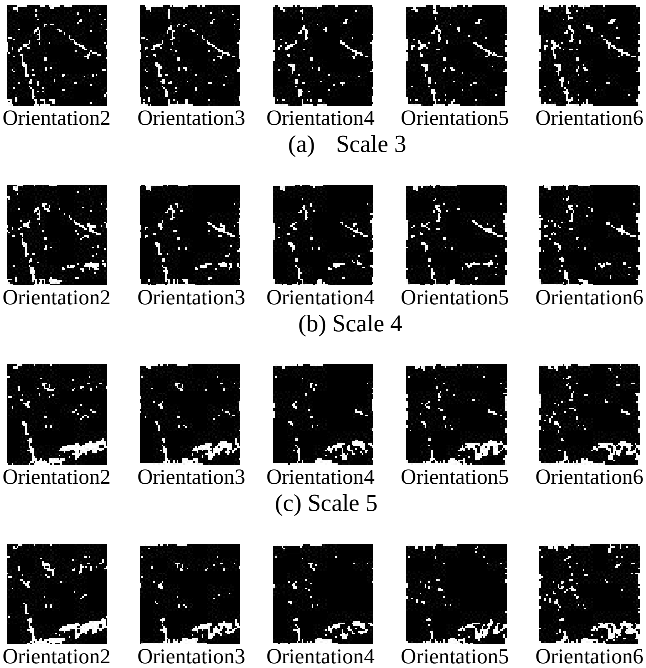


Figure 6: Binarized corner information

5. Feature Matching using Hamming distance by Sliding window method

The feature vector is compared or matched with the feature vector stored in the database. In this paper, Palmprint feature vectors are matched by Hamming distance similarity measurement method that works on binary feature vectors. The corner information (Palmprint features) extracted is binarized by the following equation (2):

$$PF(i,j) = \begin{cases} 1, PF(i,j) > 0 \\ 0, PF(i,j) \le 0 \end{cases} \quad (2)$$

where, $PF(i,j) =$ Palmprint features, i and j are the rows and columns of the Palmprint features.

The hamming distance similarity measurement between two binary feature vectors using XOR operation can be defined as:

$$HD = \sum_{i}^{64}\sum_{j}^{64}\left(FV(i,j) \oplus FV_{DB}(i,j)\right) \quad (3)$$

In addition sliding window method is used to find out the hamming distance to avoid the false rejection due to displacement of the palmprint image by some rows or columns. In sliding window method the ROI is reduced by the window size WS and the palmprint area of (64–WS) × (64–WS) pixels out of 64×64 pixels slides over the rows and columns and minimum of hamming value is considered.

Fig. 7 shows the sliding window method used to find the hamming distance.

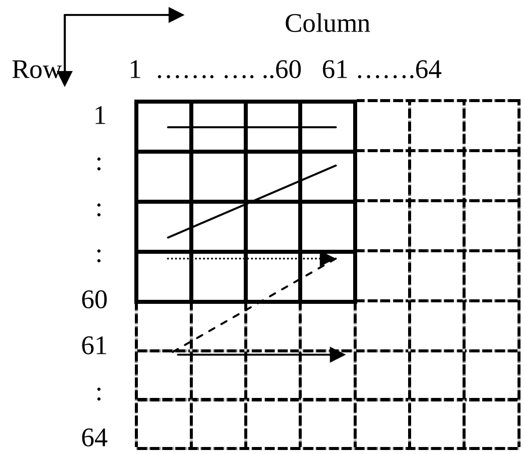


Figure 7: Sliding Window Approach with window size 4 and palmprint size 64×64

Modified hamming distance (3) with window size *WS* is defined as:

$$HD_{WS} = \sum_{i}^{64-WS}\sum_{j}^{64-WS}\left(FV(i,j) \oplus FV_{DB}(i,j)\right) \quad (4)$$

where HDWS denotes the hamming distance with window size WS, i and j is the row and column of the Palmprint feature vector, ⊕ is the exclusive OR operation, WS denotes the window size, FVDB denotes the feature vector in database.

The minimum value out of 16 (if window size is 4, there will be 4×4 = 16 hamming distance values) values of hamming distances is chosen as hamming distance from (5).

$$HD = \min\left(HD_1, HD_2, HD_3, ...HD_{16}\right) \quad (5)$$

Where, HD denotes the hamming distance value.

The hamming distance value will decide whether the person is genuine or imposter. The Hamming distance value from (5) near to 1 is identified as reference threshold. If hamming distance value between two feature vectors is less than reference threshold value, feature vectors are considered to be from same hands otherwise different hands. The authentication system is shown in Fig.

8. The accuracy of the biometric authentication can be defined by following equation (6):

$$Accuracy(\%) = \left(100 - \left(FAR(\%) + FRR(\%)\right)/2\right) \quad (6)$$

Where, FAR is False Acceptance Rate, FRR is False Rejection Rate. If either FAR or FRR is decreased, overall system accuracy is increased.

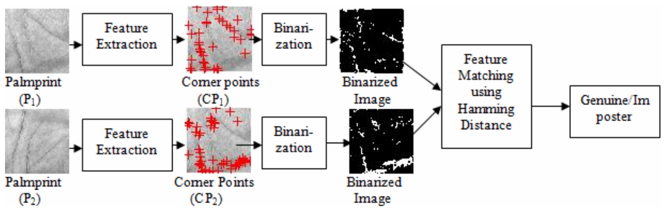


Figure 8: Authentication System

6. Reference Threshold Calculation

The reference threshold value is found out from the values stored in the database during pre-authentication system. The hand image samples are divided into two groups G1 and G2.

G1 group

$$P_1 = \lfloor I_1, I_2, ...I_{(M-1)} \rfloor, \; P_2 = \lfloor I_1, I_2, ...I_{(M-1)} \rfloor, ... \; P_N = \lfloor I_1, I_2, ...I_{(M-1)} \rfloor \quad (7)$$

G2 group

$$P_1 = [I_M], \; P_2 = [I_M], ... \; P_N = [I_M] \quad (8)$$

Where Pi denotes ith person in group G1, G2, Ij denotes the jth palm image in group G1, G2.

TABLE I: MATCHING IN GROUP G1 AMONG PERSON P1.

i \ j	1	2	3		M-1
1	X	HD12	HD13	………	HD1(M-1)
2	HD21	X	HD23	……….	HD2(M-1)
:	:	:	:	:	:
:	:	:	:	:	:
M-1	HD(M-1)1	HD(M-1)2	HD(M-1)3		X

In group G1, each hand feature vector in P1 is matched with all other (M-1) hands feature vector by Hamming distance similarity measurement method.

$$TA_1 = \begin{bmatrix} HD_{12}, HD_{13},..HD_{1M-1}, HD_{21}, HD_{23},...HD_{2M-1},...... \\ ....HD_{(M-1)1}, HD_{(M-1)2},..HD_{(M-1)(M-2)} \end{bmatrix} \quad (9)$$

Similarly, all N hand image samples matching results are stored in Threshold array (TA).

$$T_A = TA_1 + TA_2 + ... + TA_N \quad (10)$$

The minimum and maximum of matching values are found out from the threshold array (TA1, TA2,……..TAN) for each individual as shown in equation (11).

$$\left.\begin{matrix} T_{AiMIN} = \min(T_{Ai}) \\ T_{AiMAX} = \max(T_{Ai}) \end{matrix}\right\}_{i=1,....N} \quad (11)$$

The accuracy of the system is identified by matching group G2 samples with group G1 samples using threshold values stored in threshold array in (10) and (11). Finally, a threshold value is chosen where FAR and FRR is minimum, this value is called Reference threshold.

7. Experimental setup

A database of 600 palmprint images from 100 palms with 6 samples for each palm is taken from PolyU palmprint database [20]. The palmprint database is divided into two groups, first group (G1) consists of 100 persons with each person having 5 palm sample images to train the system, and second group (G2) contains 100 persons with each person having one palm image different from the first group images. Second group is used as testing sample.

Image is pre-processed to get the region of interest. The ROI size is 64×64 pixels. Feature extraction is done by Phase Congruency Corner Detector to get the corners from the palmprint image. Feature vector of all hand images samples is calculated and stored in database. Hamming distance similarity measurement method is used for feature matching.

A. Results

The results at various values of scales, orientations, number of corners, reference threshold, FAR, FRR, comparison time and accuracy are tabulated in table II. From the table II it is clear that the comparison time is independent of the number of corners detected. The maximum accuracy value is identified at scale value 3 and orientation value 6. The respective reference threshold value, FAR and FRR are values are tabulated at maximum value of accuracy corresponding to scale value 3 and orientation value 6 in table III.

TABLE II: VALUES OF PARAMETERS AT DIFFERENT SCALE AND ORIENTATION

Orientation	Scale	Reference threshold	Number of Corners	Comparison time	DB preparation time	FAR	FRR	Accuracy
2	3	9.33E-01	39	3.42E-03	8.26E-02	1.79E-01	6.83E-03	9.07E+01
2	4	9.29E-01	42	3.46E-03	9.42E-02	1.50E-01	7.14E-03	9.21E+01
2	5	9.31E-01	45	3.43E-03	1.07E-01	9.79E-02	6.55E-03	9.48E+01
2	6	9.37E-01	49	3.97E-03	1.18E-01	5.59E-02	6.37E-03	**9.69E+01**
3	3	9.36E-01	40	3.41E-03	1.09E-01	1.98E-01	6.02E-03	8.98E+01
3	4	9.35E-01	41	3.42E-03	1.23E-01	1.40E-01	6.76E-03	9.26E+01
3	5	9.39E-01	39	3.43E-03	1.44E-01	5.22E-02	6.40E-03	9.71E+01
3	**6**	**9.42E-01**	**41**	**3.42E-03**	**1.58E-01**	**4.96E-02**	**7.40E-04**	**9.77E+01**
4	3	9.43E-01	44	3.41E-03	1.34E-01	1.22E-01	6.40E-03	9.36E+01
4	4	9.38E-01	34	3.42E-03	1.52E-01	1.02E-01	6.92E-03	9.45E+01
4	5	9.38E-01	32	3.28E-03	1.78E-01	5.67E-02	6.46E-03	9.68E+01
4	6	9.35E-01	29	3.31E-03	1.97E-01	4.93E-02	6.53E-03	**9.72E+01**
5	3	9.36E-01	49	4.13E-03	1.57E-01	1.03E-01	6.63E-03	9.45E+01
5	4	9.32E-01	42	3.41E-03	1.82E-01	8.94E-02	6.38E-03	9.52E+01
5	5	9.30E-01	43	3.20E-03	2.09E-01	6.96E-02	6.37E-03	9.62E+01
5	6	9.24E-01	41	3.21E-03	2.37E-01	6.04E-02	6.90E-03	**9.66E+01**
6	3	9.30E-01	54	3.41E-03	1.79E-01	1.13E-01	6.81E-03	9.40E+01
6	4	9.26E-01	49	3.41E-03	2.11E-01	9.11E-02	6.47E-03	9.51E+01
6	5	9.20E-01	54	3.42E-03	2.43E-01	7.98E-02	6.89E-03	9.57E+01
6	6	9.15E-01	43	3.32E-03	2.79E-01	5.76E-02	6.83E-03	**9.68E+01**

TABLE III: COMPARISON OF FAR AND FRR WITH ACCURACY.

Reference Threshold	FAR	FRR	Accuracy
9.26E-01	9.62E-03	1.00E-02	9.90E+01
9.28E-01	9.35E-03	1.00E-02	9.90E+01
9.30E-01	4.31E-02	9.61E-03	9.74E+01
9.32E-01	6.87E-02	9.22E-03	9.61E+01
9.34E-01	9.68E-02	8.63E-03	9.47E+01
9.36E-01	9.83E-02	8.45E-03	9.47E+01
9.38E-01	1.02E-01	8.16E-03	9.45E+01
9.40E-01	1.22E-01	7.18E-03	9.35E+01
9.42E-01	1.13E-01	6.81E-03	9.40E+01
9.44E-01	1.26E-01	5.50E-03	9.34E+01
9.46E-01	1.23E-01	4.51E-03	9.36E+01
9.48E-01	1.11E-01	3.82E-03	9.42E+01
9.50E-01	1.03E-01	2.27E-03	9.47E+01
9.52E-01	8.67E-02	1.55E-03	9.56E+01
9.54E-01	7.29E-02	1.03E-03	9.63E+01
9.56E-01	6.07E-02	1.06E-03	9.69E+01
9.58E-01	**4.96E-02**	**7.40E-04**	**9.75E+01**
9.60E-01	4.13E-02	6.50E-04	9.79E+01

The plot between accuracy and threshold is shown in Fig. 9.

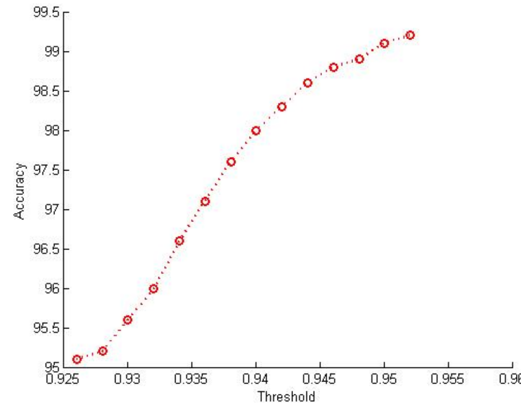


Figure 9: Accuracy Vs Threshold Range.

Plot of FAR and FRR is shown in Fig. 10.

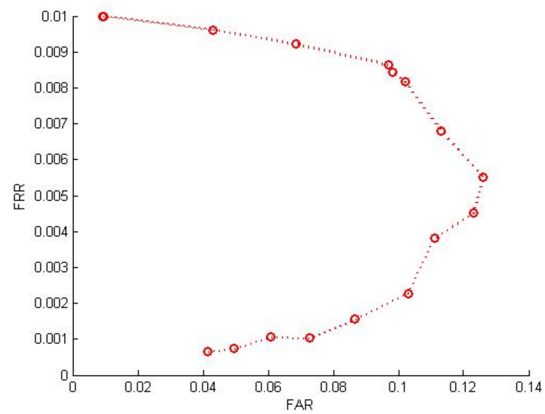


Figure 10: FAR Vs FRR

The summary of various parameters used in results are tabulated in table IV.

TABLE IV: SUMMARY OF THE VALUES USED FOR EXPERIMENTAL RESULTS

Parameters	Values
Feature Extraction method	Phase Congruency Corner Detector
Feature matching method	Hamming distance
Min Threshold	9.18E-01
Max Threshold	9.56E-01
Reference Threshold	9.42E-01
Sliding window size	2
Scale	3
Orientation	6
Comparison Time	3.42E-03
DB Preparation Time	1.58E-01
FAR	4.96E-02
FRR	7.40E-04
Accuracy	9.75E+01

The comparison of different palmprint authentication methods is tabulated in table V.

TABLE V: METHODS COMPARISON WITH PHASE CONGRUENCY CORNER DETECTOR METHOD

	Han et al. [9]	Zhang et al. [10]	Proposed Approach
Size of database	50	100	100
Feature extraction method	Sobel & Morphological	Texture energy	Phase Congruency Corner Detector
Feature Matching method	Multi-template-matching	Layered search scheme	Hamming distance
Accuracy	91	94.5	97.5%

We have found that our proposed approach has performed better than other methods.

8. Conclusion

The aim of personal authentication is to verify the person on the basis of his/her biometric features. An effective, efficient, reliable and rapid authentication system which can find the similarity/dissimilarity between two persons is required. In this paper, we have presented a promising approach of phase congruency corner detector for palmprint feature extraction. The proposed approach fulfils the requirements of the real time authentication system. The corner information extracted is stored in the feature vector. The feature vector is compared with other feature vector in the database using Hamming distance similarity measurement method. Experimental results clearly show that phase congruency corner detector methodology has the ability to discriminate similar palmprints.

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