Person Identification based on Palm and Hand Geometry

Qaisar N. Ashraf[1], Fayyaz A. Afsar[2]
DCIS, PIEAS, Nilore, Islamabad
ashrafqaisar@gmail.com[1], fayyazafsar@gmail.com[2]

Abstract

This paper proposes a new multimodal biometric system using feature level fusion of hand shape, hand geometry and palm texture. Both the palmprint and hand-shape features are proposed to be extracted from a single hand image acquired using a simple flatbed scanner. These features are then examined for their individual and combined performances. A database of 500 hand images is used to validate the performance of proposed system. By fusing the features extracted by proposed techniques i.e. PCA, Hand geometry, and wavelet transform, improvement in verification and identification is obtained. The similarity of two feature vector is measured by using Euclidean distance as similarity measure. Accuracy of the proposed system using Pieas hand database is 96.4%.

1.   Introduction

Biometric person recognition is becoming increasingly important in our information and network based society. Many physiological characteristics of humans are typically time invariant, easy to acquire, and unique for every individual. Various technologies have been proposed and implemented in the literature, including palmprint, iris, fingerprint, hand geometry, voice, face, signature, and retina identification [1]. One distinct advantage the hand modality offers is that its imaging conditions are less complex, for example a relatively simple digital camera or flatbed scanner would suffice. The palmprint and hand-shape information can be simultaneously extracted from a single hand image at medium resolution. Researchers have proposed several promising methods for palmprint recognition such as 2D Gabor filter [2], 2D Gabor filter [3], and 2D PCA and LDA [4] and hand-shape recognition such as implicit polynomials and geometric features [7], [8]. Bimodal biometric systems have recently attracted the attention of researchers and some work has already reported in the literature such as integration of face, gait and fingerprint [5] and face and iris [6]. The advantages of the proposed system are:

(i)   The security threat associated with the hand-shape biometric, due to a fake hand, can be restricted with the integration of palmPrint features.

(ii) A higher accuracy can been assured due to the usage of multimodal features.

2.   Materials and Methods

2.1   Extraction of palmprint and hand images

In order to assess the performance of the proposed system a database of 50 users (PIEAS Hand Database) is used for experiments. This database consists of 500 right hand images from 50 individuals, 10 images from each individual. In this dataset, 42 individuals are male, and the age distribution of the subjects is: about 90% are below 30 years, about 8% are aged between 30 and 50 years and about 2% are older than 50 years. The images in this database are captured using a simple flatbed document scanner (Camera Model: Hp scanjet 5590). To ensure proper hand alignment a transparent sheet with five pegs on it is placed on the scanner. These five pegs on the platform serve as control points for the placement of hands. Using pegs makes sure that the fingers don't touch each other and most of the part of the hand touches the imaging sheet containing the pegs. These pegs also reduce the time requirement for image pre-processing for hand alignment.

There are mainly three steps in hand recognition i.e. Image pre-processing, Feature extraction and Matching.
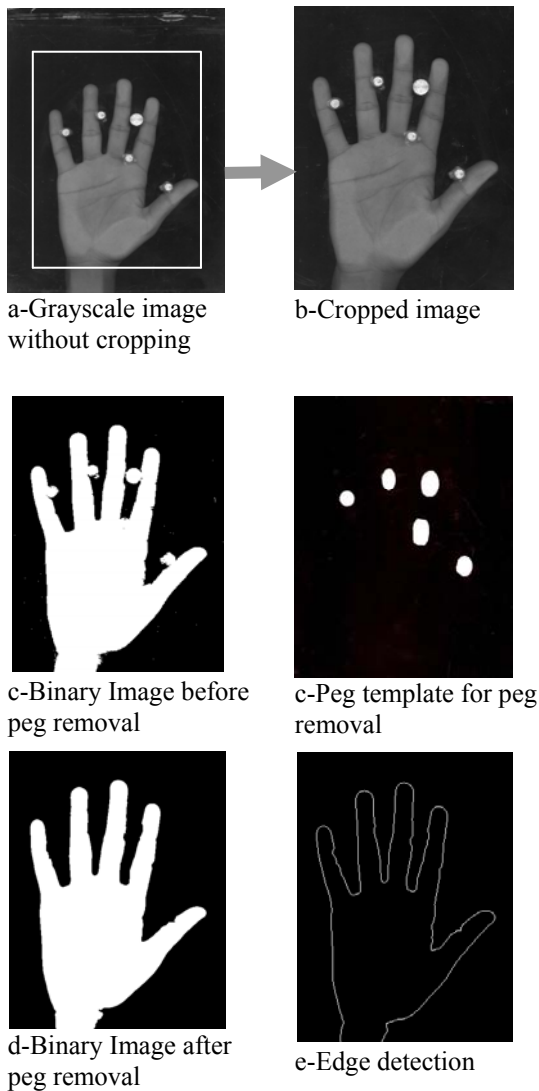
2.1.1   Pre-processing

Image pre-processing is an important step in image recognition. In the proposed system pre-processing is done as shown in figure below.
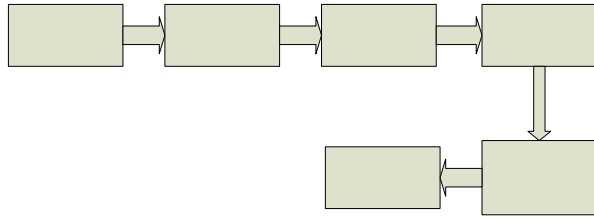
Figure 1 Image pre-processing block diagram

Input Image   Image Cropping   Grayscale Conversion   Median Filter

Peg Removal   Binarization

The input color image is cropped to eliminate the undesired portion of the image as shown in figure 1(a, b). Then the cropped image is converted to a gray scale image. A median filter of size 19-by-19 of the neighborhood is used to reduce the noise. [10]. Then to get a binary image Otsu's method [10] is used.

a-Grayscale image without cropping

b-Cropped image

c-Binary Image before peg removal

c-Peg template for peg removal

d-Binary Image after peg removal

e-Edge detection

Figure 2 Image pre-processing

Pegs are removed such that peg template $peg(i, j)$ is first negated then multiplied with the binary image $I(i, j)$.

$$I'(i, y) = I(i, y).* \neg peg(i, y)$$

After peg removing the next step of image preprocessing is the edge detection. In our proposed system, Sobel operator is used for edge detection [10].

2.2 Feature Extraction Approaches

In the proposed system three types of features are extracted from a hand image i.e. PCA based global hand shape feature, hand geometry features and wavelet domain features of palmprint. Then these feature are merged enhance the accuracy of the verification and identification of system.

2.2.1 Hand shape Feature extraction using PCA

In the proposed system PCA is used to extract hand shape features [4]. It is a common technique for finding patterns in data of high dimension. It projects images into a subspace such that the first orthogonal dimension of this subspace captures the greatest amount of variance among the images and the last dimension of this subspace captures the least amount of variance among the images [9].

In order to create an eigenspace each image is stored in a vector of size N.

$$x^i = \left[x^i_1 .... x^i_N \right] ------(1)$$

Then all the training images are mean centered.

$$x^{-i} = x^i - m, \ Where \ m = \frac{1}{P}\sum_{i=1}^{P} x^i -----(2)$$

Data matrix is created by combining these centered images.

$$\overline{X} = \left\lfloor x^{-1} \mid x^{-2} \mid ....\mid x^{-p} \right\rfloor ------(3)$$

A covariance matrix is created by multiplying the data matrix with its transpose.

$$\Omega = \overline{X}^T \overline{X} ------(4)$$

The eigenvalues and eigenvectors are computed for Ω' using eigenvector decomposition.

$$\Omega' = \Lambda' V' ------(5)$$

where V' is set of eigenvectors and Λ' is the set of eigenvalues.

Eigenvectors V of $\overline{X}\overline{X}^T$ are computed by multiplying data matrix with V'.

$$V = \overline{X}V' ------(6)$$

The eigenvectors are divided by their norm.

$$v_i = \frac{v_i}{\|v_i\|} - - - - - - (7)$$

Eigenvectors v_i are sorted according to their corresponding eigenvalues. And those eigenvectors selected which are associated with eigenvalues contain energy more than 98%. Using this threshold only 15 features are selected and remaining 235 features are discarded. Once eigenspace is created all mean centered training images are projected into it.

$$x^{\sim i} = V^T x^{-i} - - - - - - (9)$$

Each test image is centered as training images, and then these test images are projected onto the created eigenspace.

$$y^{-i} = y^i - m, \text{ Where } m = \frac{1}{P}\sum_{i=1}^{P} x^i - - - - - (10)$$

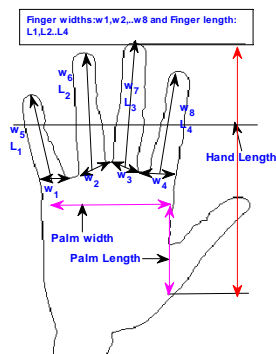And $\quad y^{\sim i} = V^T \overline{y}^{-i} - - - - - - (11)$

Using PIEAS hand database, accuracy of the proposed system by using only PCA features is about 94.5%.

2.2.2 Extraction of Hand Geometry Features

In recent years, hand geometry (Figure 3) has become a very popular access control biometrics. The characteristics of hand geometry include the length and width of palm, length and width of figures, length of hand etc.

In the proposed system binary image is used to compute significant hand geometry features. A total of 16 hand geometry features were used as shown in figure 3.
(i)   finger lengths(L_1, L_2, L_3 and L_4)
(ii)   finger widths (w_1, w_2, .. and w_8)
(iii) Palm width
(iv)   Palm length
(v)   Hand area
(vi)   Hand length

Figure 3 Hand geometry features

Using PIEAS hand database, accuracy of the proposed system by using only hand geometry features is about 91.73%.

2.2.3 Texture Feature extraction using Wavelet Transform

In proposed system texture features are extracted by applying wavelet transform on palmprints.
Image segmentation is applied to extract the palmprint images such that a square palm image of variable side length depending on the distance between the two extreme fingers is extracted. Palm print image is further segmented into four equal segments and then 2-D wavelet decomposition is applied on each segment.

Different level of decomposition is applied on palm segments but optimal decomposition level that is found was three. Similarly different wavelets are tested and best results are obtained by using dmey wavelet. Following two types of features are extracted as texture features of the palmprint.
(i)   The percentage of energy corresponding to the approximation, horizontal, vertical, and diagonal details.
(ii)   Energy of autocorrelation functions of the wavelet coefficients.

In this way we get eighty features of a palm. Feature reduction is done by applying the PCA such that those features are retained containing 98% energy. Using threshold 0.98, 40 features retained and remaining 40 features are discarded. Using PIEAS hand database, accuracy of the proposed system using texture features by applying wavelets is about 93.74%.

2.2.4 Feature Normalization

Each feature is normalized before matching score to have range [0, 1]. The normalization procedure is to transform the feature component x to a random variable with zero mean and unit variance as

$$\tilde{x_i} = \frac{x_i - \mu_i}{\sigma_i} - - - - - (12)$$

where μ_i and σ_i are the sample mean and the sample standard deviation of that feature respectively.

2.2.5 Feature Matching

Length of feature vector after integrating all techniques is 71. The similarity measure between f_1 (feature vector from the user) and f_2 (stored template) is used as the matching score and is computed as follows:

$$\omega_T = \frac{f_1 \cdot f_2}{|f_1||f_2|} - - - - - - (13)$$

If ω_T less than threshold then no match
    Else correct match

3. Results and discussions

The experiments reported in this paper utilize hand images obtained from flatbed scanner, as discussed in section above. A database of 500 hand images, 10 samples from each user is used to validate the accuracy of proposed system. The first five images from each user were used for training and the rest were used for testing. Proposed techniques can be examined for their individual and combined Performances in table 1. It clearly shows that combined techniques give better result than individuals.

Table 1 Comparisons of Proposed techniques

METHOD	PCA	HAND GEOMETRY	WAVELETS	PCA+ WAVELETS + HAND GEOMETRY
Accuracy (%)	94.5 %	91.73%	93.74%	96.4%
Number of Features	15	16	40	71
Time for training (per image)	1.5 sec.	1.65sec.	3.2sec.	6.35sec.

Accuracy of the system is measured in terms of FAR and FRR for different thresholds and the same is plotted (Figs.4) to get the optimal threshold for the system with low false acceptance and low false rejection rates. At optimal threshold i.e. 0.66, accuracy is about 96.4%.
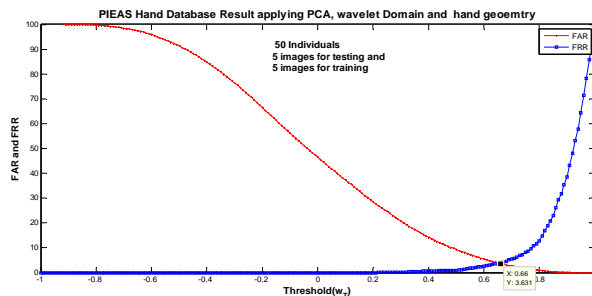
Figure 4 False acceptance rate and false rejection rate

Different techniques are implemented in the literature. A comparison of these techniques is shown in table 2.

Table 2 Comparison of different techniques implemented in literature

TECHNIQUE	DATABASE (NO. OF PERSONS)	ACCURACY (%)
2D Gabor phase coding scheme [2]	386	99.4
PCA[12]	160	85.63
2DPCA[12]	160	99
Liang Li, Xin Yang (F.Mellin Transformation) [13]	386	95.1

4. Conclusions

This paper introduces a new approach for person identification and verification based method based on palmprint and hand geometry features. A palmprint image contains the texture information and wavelet transform is applied to extract the texture features. PCA is applied to extract the hand shape features. By the integration of features extracted by proposed techniques i.e. PCA, Hand geometry, and wavelet domain analysis of palm, a higher performance is achieved. Experimental results suggest that majority features of hand are useful for person recognition. Using PIEAS hand database, accuracy of the proposed system is about 96.4%.

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