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Enhancing the Performance of Palm Biometric Verification System

Dr. Ikvinderpal Singh
PG Department of Computer Science & Applications,
TSGGS Khalsa College,
Amritsar
Email: ips_sikand@yahoo.com

Kanwarpal Singh
PG Department of Computer Science & Applications,
BBKDAV College for Women,
Amritsar

***Abstract*—** In this paper, we presents a palm biometric verification system based on palm print, heart line shape and geometric feature of human hand. The hand image captured using digital camera is preprocessed to find the palm print ROI (region of interest) that has heart line. Palm print texture features are extracted by applying local binary pattern method and Gabor filters are applied on palm ROI to extract heart line feature. Geometry features are represented as distances between different boundary points located on palm region of hand. A simple yet robust decision level AND rule is proposed for developing an efficient biometric based person verification system. The proposed system is tested on database collected at our institute. The equal error rate (ERR) of the proposed system is 2.56%. Experimental results clearly indicate that combining heart line shape and hand geometry feature with palm print features at decision level improves the performance of the verification system.

Keywords *: biometrics, Gabor Filter, palm print, principal lines, verification*

I. INTRODUCTION

Biometric system is becoming increasingly important, since they provide more reliable and efficient means of identity verification. The physical dimensions of a human hand contain information that is capable of authenticating the identity of an individual. Hand geometry based identification systems utilize the geometric features of the hand like length and width of the fingers, diameter of the palm and the perimeter.

Biometrics is of three modes i.e. unimodal biometrics which can identify individual by using single trait. Second is bimodal biometrics in which identification is done with fusion of two modalities and the other is multimodal biometrics which uses combination of multiple traits for identification purpose of human. A unimodal biometric may fails to be accurate enough for the identification of a large user population and there is one more possibility of failure if physical characteristics of a person for the selected biometric is not available [1].

Multi-model biometric systems are gaining acceptance due to performance superiority over unimodal systems which are limited as regards with accuracy, processing time and vulnerability to spoofing [2]. Multimodal biometrics advantages are reported in literature. It indicates that combining a user's multiple sensors, biometric features, units, matchers or enrolment templates could improve biometric system accuracy. Multi-model biometric systems are designed to mix various biometric data at different levels like feature extraction level, score level or decision level.

Many factors are to be deliberated when designing multimodal biometric systems: (1) nature and number of traits (2) level at which information provided by biometric traits is integrated (3) method to integrate information (4) relationship between cost and performance. Multimodal biometric systems represent two/more combined biometric recognition technologies. They ensure higher security as more than one identity indicator is requested from users making it hard for intruders to fool systems as many fake identities would be needed simultaneously.

Biometrics system has two types i.e. verification systems and identification systems. In a Verification System the input is a claimed identity and a biometric record. The system compares that biometric record with the biometric record stored in database for that identity to verify the claimed identity. In this system only a comparison is performed. In an Identification System the input is a biometric record. The system must search a database looking for the biometric data most similar with an input query biometric data and must decide if both of them belong to the same person. Many comparisons are required for this system [3,4]. The most frequently used measures to rate the accuracy of a biometric authentication system are as follows: false-accept-rate (FAR), the frequency with which an impostor is falsely accepted; and false-reject rate (FRR), the frequency with which a genuine user is rejected. The error rate at which the FAR equals the FRR, the equal-error-rate (EER), is (normally) used as a comparison metric for different biometric systems

The focus of this work is to observe the improvement in the performance when more features are integrated and to analyze the suitability of the selected features in developing a biometric based recognition system to operate in verification mode [5, 6].

II. RELATED WORK

Several research work on hand related traits have been reported in biometric literature. The palm is the inner surface of the hand between the wrist and the fingers. The palmprint is a rich source of information that is useful for personal authentication. The most important features are the three principal lines (the heart line, the head line, and the life line), wrinkles, and ridges. Palmprint-based biometric (*on-line* or *off-line*) systems can be classified according to the applied feature generation method into systems that extract features in the *original image space* or in the *transformed image space*.

M. Wang, et al [7] proposed 2D PCA and 2D LDA over conventional PCA have been reported to be better for palmprint recognition. V. Conti, et al [8] have proposed multimodal biometric system using two different fingerprints. The matching module integrates fuzzy logic methods for matching score fusion. Both decision level fusion and matching score level fusion were performed. Antonia Azzini, et al [9] given idea about using a fuzzy control system to manage a multi-modal authentication system, checking the identity of a user during the entire session. The first biometric acquisition takes matching score 0.725and the second biometric acquisition takes score 0.4860. Kornelije Rabuzin, et al [10] had suggested active rules in fuzzy logic are used for effective decision making in person identification. The recognition rate is 97%. Gawande, et al [11] used log Gabor filter can be used to extract the feature vectors from both Iris and Fingerprint and then they are concatenated. The phase data from 1 D log Gabor filters is extracted and quantized to four levels to encode the unique pattern of Iris and Fingerprint into bitwise biometric template. Hamming distance (HD) is used to generate a final match score. Yong Jian Chin, et al [12] proposed a multimodal biometrics system in which 2D gabor filter is used to extract features. The recognition rate is 95.8%. Nicolas Tsapatsoulis, et al [13] presented an identification and authentication system based on hand geometry which used POLYBIO hand database. The recognition rate is 95%.

Anil K. Jain, et al [14] given an overview of biometrics, emerging biometric technologies and their limitations, and examines future challenges. Mohammad Imran, et al [15] proposed a new hybrid approach to verification aspect of a multibiometric system and comparative analysis with traditional approaches such as multialgorithmic and multimodal versions of the same. The average EER of hybrid approach from different levels of fusion is 3.87% which shows that hybrid approach yields lower average EER. Romaissaa Mazouni, et al [16] proposed a comparative study of several advanced artificial intelligence techniques (e.g. Particle Swarm Optimization, Genetic Algorithm, Adaptive Neuro Fuzzy Systems, etc.) as to fuse matching scores in a multimodal biometric system is provided. The fusion was performed under three data conditions: clean, varied and degraded. Some normalization techniques are also performed prior fusion so to enhance verification performance. The population based techniques (PSO, GA) gave very good results. Nishant Singh, et al [17] presents an efficient multimodal biometric system based on 4 slap fingerprint images. The system utilizes 4 slap fingerprint scanner to simultaneously collect fingerprints of multiple fingers on a hand in one image**.** Decision threshold is 0.9869 and FAR is 5.08%.

III. PROPOSED WORK

The block diagram of the proposed verification system is shown in figure 1. The proposed method includes various steps such as image acquisition of user from sensor, pre-processing operation to enhance the quality of image and feature extraction process to identify the features of an image. Finally, matching is done on the basis of specific features with database image and decision is made for identification.

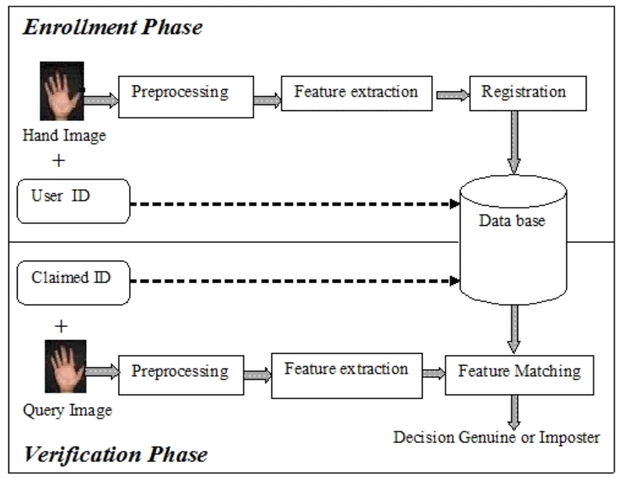

Fig. 1. Proposed Approach.

This system works in four stages:

A. Image Acquisition

B. Preprocessing Module

C. Feature Extraction

D. Verification module

First stage consists of image acquisition and preprocessing module. Second stage and third stage consists of feature extraction and recognition modules respectively; Preprocessing module employs image processing algorithms to locate key points on palm region of hand. Key points are used to find ROI (region of interest) of palm print. Feature extraction module extracts features of hand geometry and palm print by utilizing palm print ROI. Heart line features are extracted from the palm ROI. Finally the verification module utilizes minimum distance classifier according to Euclidean distance for confirming the identity as genuine or denying a person's claimed identity as imposter. This process is done by comparing palm print query template with the palm print templates of claimed identity stored in the database during enrollment. Hand geometry and heart line features are used with palm print features to enhance the performance of verification system.

A. Image Acquisition

An image acquisition set up is designed to acquire hand images. A digital camera mounted on a tripod stand is focused against a black panel under normal room lighting conditions to capture hand images. The camera is placed at a suitable distance from the panel. During image acquisition we requested the user to position their hand in front of the panel with the palmer side of the hand region facing the camera. There is no guidance or pegs to restrict the users hand placement. Our data collection process was carried out at two different locations which had no restrictions on surrounding illuminations. The data collection process spanned over three months and 556 persons volunteered for the database. Four hand images of each individual were captured in two sessions resulting in 8 images per individual leading to a total of 4448 images in the database. Complete image database is divided into two mutually exclusive gallery (training) and probe (test) sets. Let $Dbase_G = \{IG_1, IG_2, \ldots\ldots IG_N\}$ be the gallery set database consisting of N hand images and $Dbase_P = \{QP_1, QP_2, \ldots\ldots QP_M\}$ be the probe set database consisting of M hand images.

B. Pre-processing Module

Pre processing process involves the following steps.

- Captured color image is converted to gray level image.
- A fixed threshold is applied to convert the gray image into a binary image.
- Hand contour is obtained and three key points between finger valley positions are identified as per the algorithm proposed in [18]. Identified points P_1, P_2, P_3 are as shown in fig 2a.

ROI of palm print is the rectangle region selected using the points P_1 and P_3. The width of ROI is considered as the distance between P_1 and P_3 and top left corner of rectangular region is selected 20 pixels just below P_1. The ROI part containing the palm print is cropped out of the main image and then resized to a size of 125 X 125 pixels. The resized palm print ROI image undergoes no further pre processing. Identified palm print ROI and extracted ROI are shown in Fig. 2b and 2c respectively.

C. Feature Extraction

To verify the identity of an individual, it is essential to store the individual's characteristic features extracted from the data acquired using image acquisition set up. Feature extraction algorithms are applied on the preprocessed input data to compute feature vectors. Instead of input data these feature vectors are stored in the data base and are called as templates.

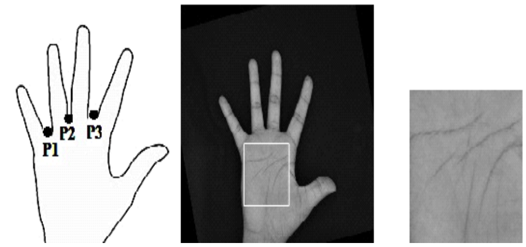

Fig. 2a. Key points. Fig. 2b. ROI Location. Fig. 2c. Palm ROI.

1) *Palm print feature extraction*

Local binary pattern (LBP) has been widely used to extract texture information from biometric images [19]. The local binary pattern operator transforms an image into an integer labels describing small-scale appearance of the image. The LBP operator assigns a binary label to every pixel in the image by thresholding it against the eight neighbor pixels. If the pixel's value is greater than the neighbor pixel value a value 1 is assigned, otherwise 0 is assigned. A binary label is called uniform if it consists of at most two bit-wise transitions from 0 to 1 or vice-versa. For example 11101111 and 11111101 are uniform binary labels whereas 10101111 and 01011011 are non-uniform. There are 58 labels of uniform patterns and the rest 198 labels are non-uniform. A label is given to each of the uniform patterns, and all other non-uniform patterns are assigned to a single label resulting in 59 labels. After all the labels have been determined, a histogram H_l of the labels is constructed as

$$H_l = \sum\{L(i,j) = l\}, \ l = 0, \ldots, n-1$$

Where n is the number of different labels produced by the LBP operator, while i and j refer to the pixel location. LBP histogram calculated from palm print ROI are stored as feature vector of 59 dimensions. The matching of the palm print gallery and probe template is done by computing the distance between the two templates. The Euclidean distance metric is used as it achieves good results at low computational cost. Euclidean distance between two templates is defined as

$$d(P,G) = \sqrt{\sum_{i=1}^{n}(P_i - G_i)^2}$$

Where P and G are templates to be compared. The larger the distance between the two templates the more dissimilar are the two images. At the verification stage a threshold T is used to regulate the system decision at matching stage. If the Euclidean distance is less than or equal to T, then the templates are considered to belong to the same individual else they are considered to belong to different individuals.

2) *Heart line shape identification*

Gabor filters have been widely used for extracting orientation information, a 2D Gabor filter is used.

For identifying heart line shape following steps are used.

- The palm print ROI image is convolved with a bank of Gabor filters sharing the same parameters, except the orientation parameter. Orientation along four directions

30, 45, 60 and 75 degrees are considered resulting in four different images.

- Sum of all the four images is computed.
- Morphological thinning operation is performed to reduce the line thickness. Gap between nearer lines are identified and are joined with isolated spikes being removed from the image.
- A line L is drawn between the end points of heart line and slope m of the line L is compued. Eight equi distance points are identified on the heart line (d_1 to d_8).Lines (l_1 to l_7) are drawn between adajecnt equi diatance points and slope of lines SL_i are computed. Deviation of the heart line from the line L is computed.

If (deviation is less than 1)
then category = 1 (heart line is straight)
else if(deviation is greater than 4)
then category = 2 (heart line is curved)
else if (the slope of lines SL_1 to SL_5 is less than 10)
then category = 3 (heart line is straight and slant)
else category = 4 (heart line is straight at start and little bit curved at end)

Category value is stored as shape feature vector of one dimension. Sample heart line shape for all the four categories are shown in figure 3.

*3) **Hand geometry feature extraction***

Key points P1, P2 and P3 identified during pre processing stage are used for feature extraction. The angle between the line joining the points P1,P2 and P2,P3 is calculated. The angle value is stored as hand geometry feature vector of one dimension. In order to check the suitability of this feature, two hand images of the same person taken in two sessions were selected. The two angle values obtained were 151 and 156 degrees respectively. Two such sample images are shown in figure 4a and 4b. We observed that even though spacing between fingers are different there is not much difference in the angle values computed for first session and second session images. Let d(Tg,Tp) denote the difference value computed for pair of hand geometry templates, where Tg and Tp denotes gallery set and probe set templates respectively.

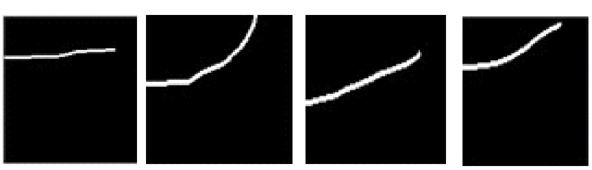

Fig. 3. Heart line shape types.

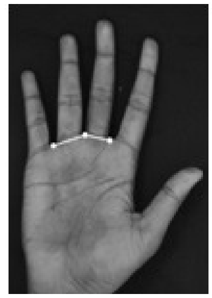

Fig 4a. Hand image of sample 1

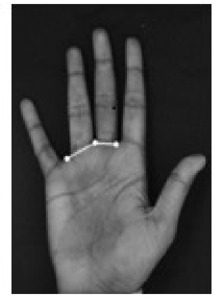

Fig 4b. Hand image of sample 2

For each individual Euclidean distance of every probe template with the four gallery set templates of the same individual are computed.

D. Verification Module

The task of verifying the claimed identity of an individual is considered as a two class classification problem with class label as Genuine and Imposter. A sequential rule is formulated for decision making purpose and steps carried out in this phase for verifying the claimed identity of an individual as either Genuine or Imposter are as follows.

- For a query image q with claimed identity perform preprocessing and feature extraction procedure to get the query angle feature vector , heart line shape feature vector and palm print feature vector .
- Retrieve the angle feature vector , heart line shape feature vector and palm print feature vector computed during enrolment for the identity (probe template) from the database.
- Compute Euclidean distance between and query palm print feature vector and probe palm print feature vector .
- Let denote the comparison between pair of heart line feature templates. It is assigned with a value of 1 if both values are same else is assigned with a value of 0.
- Compute as the difference between the two angle feature vectors.

If ( ) then label = Genuine
else label = Imposter

IV. EXPERIMENTAL RESULTS

In order to evaluate the performance of the proposed approach, verification experiments were conducted on the collected database. The performance of proposed system is measured using equal error rate (ERR) which is the value of false acceptance rate (FAR) for which FAR and false rejection rate (FRR) are equal. FAR is the percentage of authorized individuals that the biometric system fails to accept and FRR is the percentage of unauthorized individuals that the biometric system fails to reject. FAR and FRR. Threshold value of the system is obtained based on ERR criteria since both FAR and FRR must be as low as possible for the biometric system to work effectively. ERR value obtained for all the three experiments for verifying the identity of an individual are tabulated in Table 1. Results obtained clearly indicates that by using more than one trait for verifying the identity ERR can been reduced. Also with respect to verification scheme major work reported in literature is with images being acquired using scanners and pegs being used to fix the placement of hand. Where as in our work we have captured images under normal room lighting conditions and major challenge is in extracting features which are invariant to illumination. Proposed system with ERR of 2.53% is able to achieve similar performance to that reported in [20] which uses a contactless image acquisition setup with ERR of palm print verification being 2.16%.

TABLE 1Verification performance of proposed approach.

Biometric trait used	ERR
Palm print	9.52%
Palm print + Heart line	6.8%
Palm print +Heart line + Angle feature	2.56%

V. CONCLUSIONS

This proposed system is of significance since all the three traits can be extracted from the palmer region of the hand with the images being acquired with a contactless image acquisition set up. The proposed system is reliable for medium range security applications as it achieves an ERR of 2.56%. The objective of this work was to investigate the integration of palm print, heart line and geometry features to achieve better performance that may not be achievable with using unimodal biometric traits. Further investigation of this work includes identifying other hand related traits and investigating how well identified traits reduce ERR. By reducing ERR security level of the system can be enhanced.

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