Hand Image Analysis for Personal Authentication

Jayashree I. Kallibaddi, S.M. Hatture and Sadanand R. Inamdar

Abstract--- *In a networked society providing authorized users with secure access to the services is a challenge for the personal identification systems. Biometric systems provide an authentication for real world applications. Developing new efficient biometric system by analyzing user hand image is proposed in this paper. This paper attempts to improve the performance of hand-geometry based identification system by integrating palmprint features. Hand-geometry and palmprint features can be collected simultaneously from the same hand image. Fourteen different hand-geometry distances are extracted from the hand image. Texture information from palmprint is extracted using Symmelt-8 wavelet transform. Both hand-geometry and palmprint features are combined at feature level. The identification of the user is carried out using Euclidean distance classifier. The proposed bimodal biometric identification system is tested for 100 persons of GPDS 150 right-hand image database. Experimental results show that the designed system achieves an acceptable level of performance and can be used in high security applications.*

Keywords--- *Biometrics, Hand-Geometry, Palmprint, Wavelets, Texture Analysis, Feature Level Fusion, Euclidean Distance*

I. INTRODUCTION

BIOMETRICS is an emerging technology [1] that is used to identify people by their physical and/or behavioral characteristics so, inherently requires that the person to be identified is physically present at the point of identification. The physical characteristics of an individual that can be used in biometric identification/verification systems are fingerprint, hand geometry [2], palm print [3], face, iris, retina and ear. The behavioral characteristics are signature, lip movement, speech, keystroke dynamics, gesture, and gait. Biometric systems based on a single biometric characteristic are referred to as uni-modal systems. They are usually more cost efficient than multimodal biometric systems. However, a single physical or behavioral characteristic of an individual can sometimes fail to be sufficient for identification. For this reason, multimodal biometric systems which integrate two or more different biometric characteristics are being developed to provide an acceptable performance, to increase the reliability of decisions and to increase robustness to fraudulent technologies [4]. The biometric community puts a lot of effort into working on technical standards in the field of biometric fusion [5]. Although systems based on fingerprints and eye features have, so far achieved the best matching performance, the human hand also contains a wide variety of features e.g., shape, texture, and principal palm lines that can be used by biometric systems. These features of the human hand are relatively stable and the hand image from which they are extracted can be acquired relatively easily. Furthermore, it has been reported [1], [6] that identification systems based on hand features are the most acceptable to users.

This paper gives an overview of the physiological biometric system that uses hand based characteristics namely palmprint and hand geometry. The paper is organized as follows. The Section II presents related work with various approaches used in hand geometry and palmprint based biometrics. Section III discusses the architectures of proposed work. Results are discussed in section IV. Section V gives conclusion.

II. RELATED WORK

Two kinds of biometric indicators can be extracted from the low-resolution hand images; (i) Hand geometry features, which include area/size of palm, length and width of fingers and (ii) palmprint features, which are composed of principal lines, wrinkles, minutiae, texture information etc.

The problem of personal identification using palmprint features has drawn considerable attention and researchers have proposed various methods. One popular approach considers palmprints as textured images which are unique to every individual. Therefore, analysis of palmprint images using Gabor filters [7], Wavelets [8], Fourier transform [9], and local texture energy [10] has been proposed in the literature. The endpoints of some prominent principal lines, i.e., the heart-line, headline, and life-line are rotation invariant. Some authors have used these endpoints and midpoints for the registration of geometrical and structural features of principal lines for palmprint matching. Duta *et al*. [11] have suggested that the connectivity of extracted palm lines is not important. Therefore they have used a set of feature points along the prominent palm lines, instead of extracted palm lines, to generate the matching score for palmprint authentication. Chen *et al*. [12] attempted to estimate palmprint crease points by

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generating a local gray level directional map. These crease points are connected together to isolate the crease in the form of line segments, which are used in the matching process. Some authors have used fixation pegs to restrict the hand movement and shown promising results. However, the results may be biased by the small size of the database and an impostor can easily violate the integrity of system by using fake hand.

Golfarelli et al. described an on-line biometric system based on 17 hand-geometrical features, extracted from the image by means of an ad-hoc feature-extraction algorithm. Jain et al. [14] described the prototype of an on-line verification system based on 16 hand-geometrical features: the length, the width and the thickness of fingers and the width of the palm. In papers [15], [16], [17], [18] the fusion of hand-geometry and palm print features at the matching-score and decision levels are described.

III. PROPOSED WORK

In this proposed system the features of hand geometry and palmprint are combined at feature level rather than at decision level to identify the user. The architecture of the proposed work is shown in Fig. 1.

Architecture involves the steps namely, image acquisition, image pre processing, land mark detection, feature extraction for hand-geometry and palmprint, template generation, matching and decision.

A. Hand-Geometry Features Extraction

Image acquisition is the first step to acquire the hand image. The proposed system uses images from General Primary Data Sources (GPDS) 150 hand image database. The database consists of 10 different acquisitions of 150 people by a desk scanner. The 1500 images have been taken from the user’s right hand.

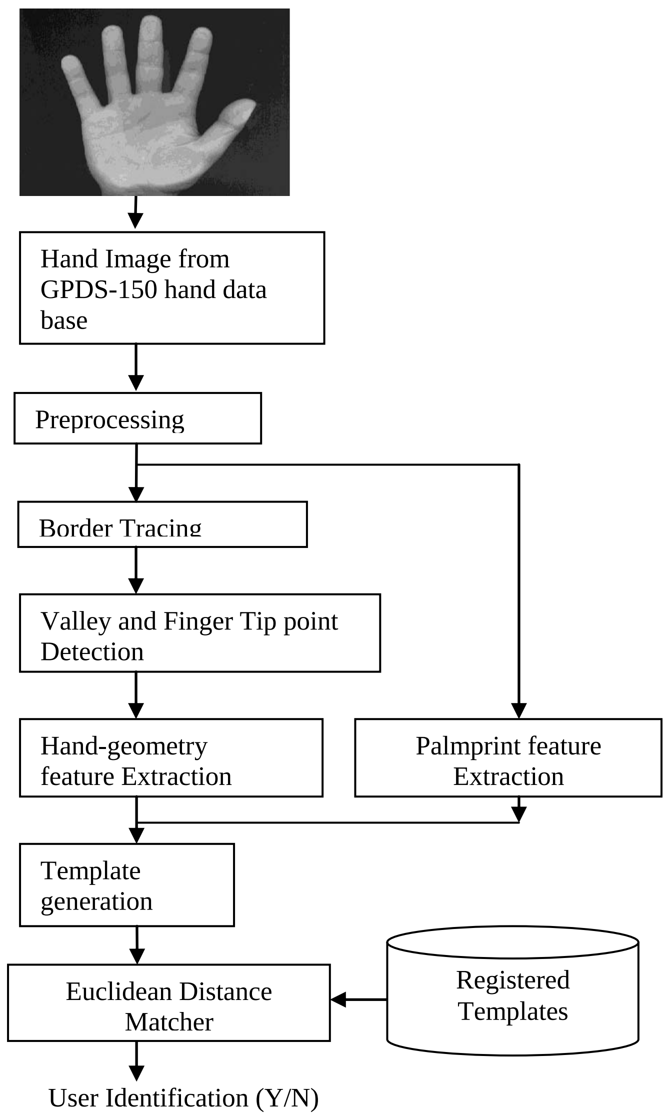

Figure 1: Architecture of Proposed Work

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To make images ready for further feature extraction, image pre-processing in this proposed work uses steps like image resizing, binarization, and edge detection. Original images are resized to 50% using nearest neighbor interpolation. Resized image is converted into binary image where each pixel is represented by either 0 or 1. Segmented edge image is obtained using canny edge detection method from the binarized image.

After edge detection hand contour is traced to detect valley and finger tip points. Using these land marks, fourteen hand geometry features namely length of little finger, ring finger, middle finger, index finger, distances from centroid of palm to four finger tip points, distances from centroid of palm to five valley points and palm width are extracted as shown in Fig. 2. These extracted features are concatenated to form a feature vector of length fourteen.

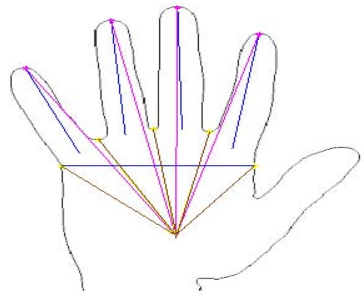

Figure 2: Fourteen Hand Geometry Features

B. Palmprint Features Extraction

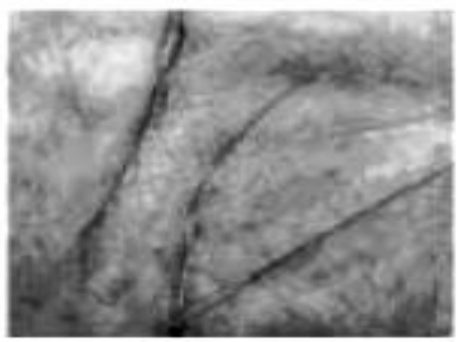

Figure 3: ROI of Palmprint Image

Palmprint is rich in texture information. Region of Interest (ROI) of palmprint image is shown in Fig.3. We use Symmelt-8 wavelet for the textural analysis of palmprint. It can easily be combined with hand geometry based personal identification system.

Gray level images retain all the useful discriminating information required for personal identification, along with considerable reduction in processing time. The gray level images are normalized and thresholded to get a binary image. Hysteresis thresholding has been adopted due to its effectiveness in varying illumination conditions and undesirable background noise.

The longest line in a palm passes through the middle finger, and any rotation will be considered with reference to this line. After the vertical alignment of the palmprint, morphological operation of dilation is applied to remove holes in the binary image. The image is complemented and finally distance transform is used with the chessboard metric to calculate the centre of palmprint.

The distance transforms evaluates the pixels which have a value of zero for their nearest non-zero neighbors and the maximum distance obtained from the distance transform is estimated to be the centre of palmprint. The mathematical equation for the chessboard metric is defined as;

$$d = \mathrm{Max}\ [(x1-x2)\ \mathrm{II}\ (y1-y2)] \quad (1)$$

A fixed square region of 256 x 256 pixels is cropped around the calculated centre of palmprint. The obtained registered palmprint image can be analysed for its texture using Symmelt-8. The palmprint region 256x256 has been decomposed into three scales. This resulted in ten directional details for Symmelt-8 wavelet. Neglecting the approximation level, normalized energy is calculated for each block. As texture analysis in palmprint is adversely affected by the variations in illumination, compute the normalized energy of the decomposition blocks so as to minimize feature variance due to non-uniform illumination. The energy computed from each block for the Symmelt-8 wavelet types is concatenated to form a feature vector of length 9 for an individual

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palmprint. The extracted palmprint texture feature is shown in Fig. 4.

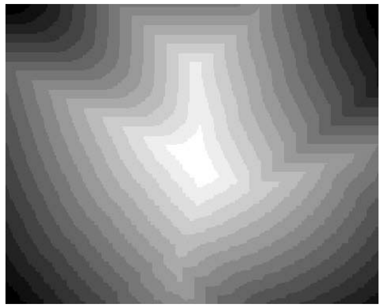


Figure 4: Texture Feature of Palmprint

C. Fusion and Identification

In this developed system hand geometry feature vector is combined with palmprint feature vector at feature level. The combined feature vector of length twenty-three obtained from the input image is matched against the combined feature vector of images (template) stored in the data base using Euclidean distance. Euclidean distance between two vectors is calculated by squaring the difference between corresponding elements. For p(x, y) and q(s, t) the Euclidean distance between p and q is defined as:

$$\mathrm{De}(p,q) = \sqrt{(x-s)^2 + (y-t)^2} \quad (2)$$

After calculating the matching score, the system compares the result with a predefined threshold and classifies the claimer. The system identifies the claimer if and only if the calculated match value is lower than the threshold, and it rejects the claimer if the match value is higher than the threshold.

IV. Experimental Results

In identification process, Correct Recognition Rate (CRR) or Correct Identification Rate (CIR), False Rejection Rate (FRR) and False Identification Rate (FIR) are the important parameters. CIR (CRR), FIR and FRR are defined as follows

$$\mathrm{CIR} = (\mathrm{NCI}/\mathrm{NQS}) \times 100 \quad (3)$$

$$\mathrm{FIR} = (\mathrm{NWI}/\mathrm{NQS}) \times 100 \quad (4)$$

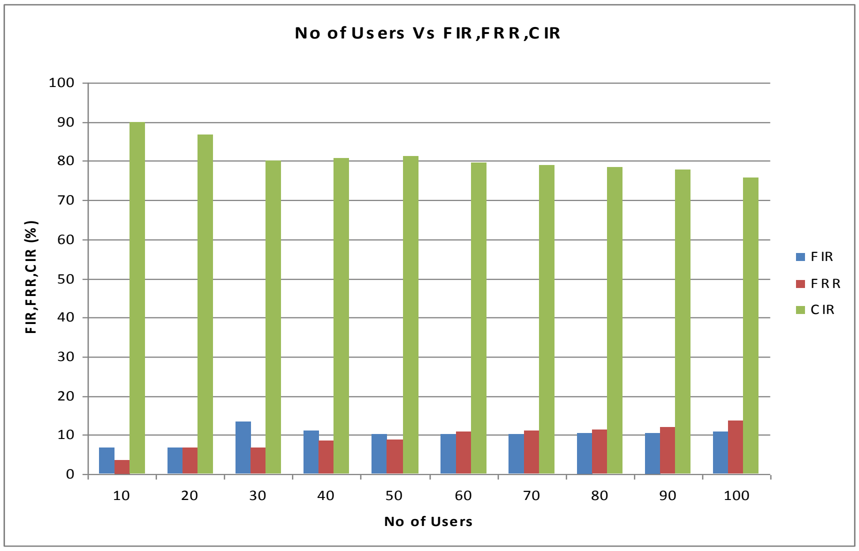
$$\mathrm{FRR} = (\mathrm{NWR}/\mathrm{NQS}) \times 100 \quad (5)$$

Where NQS = total number of query samples, NCI = total number of correctly identified samples, NWI = total number of wrongly identified samples and NWR = total number of wrongly rejected samples. The above said performance metrics are calculated for the proposed biometric system by setting threshold value to 75. The calculated performance metrics are as shown in the Table 1.

Table 1: Performance Metrics

No. of Users	CIR in %	FRR in %	FIR in %
10	90.00	3.33	6.67
20	86.67	6.67	6.67
30	80.00	6.67	13.33
40	80.83	8.33	10.83
50	81.33	8.67	10.00
60	79.44	10.56	10.00
70	79.05	10.95	10.00
80	78.33	11.25	10.42
90	77.78	11.85	10.37
100	75.67	13.67	10.67

The three different performance metrics CIR, FRR and FIR calculated in percentage for different number of users are shown in the graph below.



Graph 1: Performance Metrics Vs Number of Users

V. Conclusion

In traditional identification methods any person with the claimed identity will be given authorization. Therefore, it is desirable to identify the person based on "who he/she is?" Biometric person identification is a solution to this problem, in which the person is identified, based on his/her physical or behavioral traits. The objective of this work is to integrate hand geometry and palmprint features at feature level and to achieve higher performance that may not be possible with single biometric system alone. The achieved results are significant since two biometric traits are derived from the single image. The image resolution required is low when compared to other biometric systems. This proposed work attempts to improve the performance of hand geometry identification system by integrating palmprint features. To improve the recognition rate, this system can be further combined with other hand features like, palm vein, principle lines, finger print, finger width, hand shape and so on.The experiments can be carried out for more than 100 users. The use of Neural Network classifier, Support Vector Machine, etc may result in further improvement of the system accuracy.

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