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Survey of Advanced Palmprint Recognition Systems

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ABSTRACT: Biometric systems are essentially referred to pattern recognition systems which provide personal identification schemes to verify the identity of a person based on the feature vector(s) obtained from their physiological or behavioral characteristics possessed by the person. Palm print authentication has gained much attention recently and has been explored over last decade because of its stable line features, unique characteristics, low-price capture device, user-friendly, fast execution speed also it gives a larger area for feature extraction. Palm print is essentially the patterns of lines e.g. principal lines, coarse lines, ridges and wrinkles etc. placed on the palm area of a person. A person can be identified by their palm print because it possesses various unique attributes such as palm-color, line clarity, intensity, position, length, and thickness of those lines etc. Palm print verifies an individual based on the principal lines, coarse lines, ridges and wrinkles of the palm. The identification process can be categorized into the steps of image acquisition, pre-processing, feature extraction, matching and result. This paper attempts to cover the current palm print research, verification algorithms, different techniques used for palm print verification and their respective advantages and disadvantages.

KEYWORDS: Biometric, palmprint, authentication, verification, identification.

I. INTRODUCTION

Biometric systems have gained much attention in the field of personal verification recently. Biometrics can be broadly categorized into two categories behavioral and physiological as shown in Fig -1. In biometric system, physiological characteristics are more reliable in comparison to the behavioral characteristics. Palmprint falls under the category of physiological category. Identification of palmprint uses the user's palm as a bio-metric for identifying that person. Palmprint focuses on the inner surface of a hand and Palmprint patterns are a authentic biometric and it requires less cooperation from the person for palmprint extraction. Palmprint is unique, easy to capture by low resolution devices as well as comprises of features such as principal lines, wrinkles and ridges, minutiae, datum point and texture images. Thus it is suited to everyone and it does not necessitate any personal information of the person.

There are mainly three flexion creases, secondary creases and ridges present in the inner part of the palmprint between the wrist and fingers as shown in Fig -2 [11]. The flexion creases are knows as principal lines and the secondary creases are known as wrinkles. The flexion and the major secondary creases are shaped within the 3rd and 5th months of pregnancy [2] and superficial lines are shaped after birth. There are three main principal lines such as heartline, headline and lifeline. Wrinkles are coarse lines and ridges are fine lines of the palmprint.

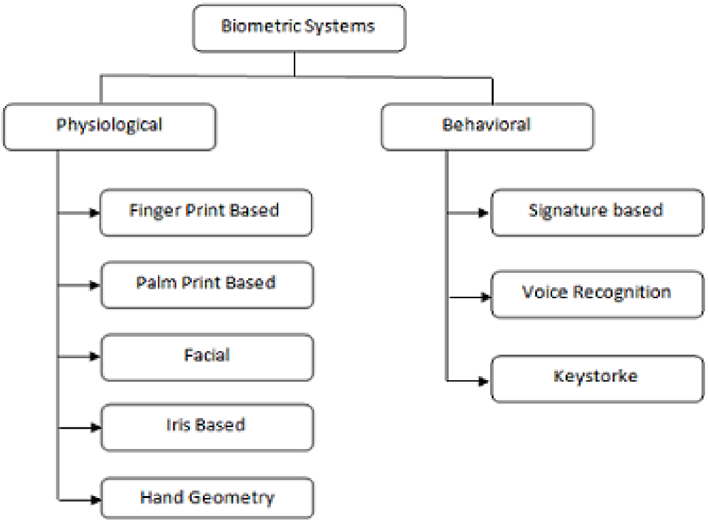
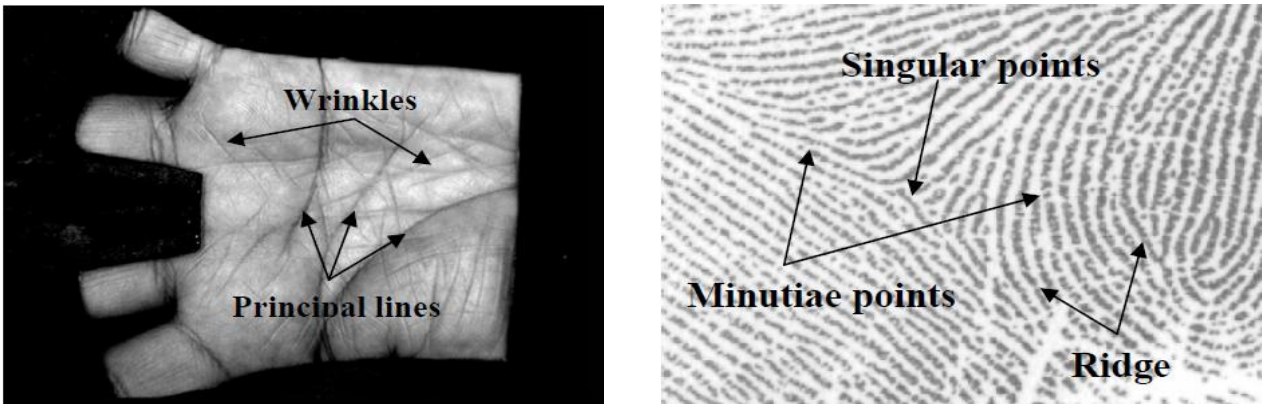


Fig -1: Biometric Systems Classification

As a wide application, Palmprint recognition can be used in both off-line as well as in on-line mode. Basically high resolution images are used for the off-line applications such as criminal detection and on the other hand low resolution images are used for On-line applications like civil and commercial application. In low resolution images only principal lines, wrinkles are extracted but in high resolution images generally all the features can be extracted. Low resolution images are used In case of real time applications as they require less memory for storage and have fast matching speed.



(a) (b)

Fig -2: Palmprint features (a) low resolution image and (b) high resolution image

There are three modes in which palmprints are operated: enrollment, identification and verification .In case of enrollment mode, various palmprint samples have to be presented by the user to the system. In Verification mode the comparison is done with only those templates comparable to the claimed identity. The process of Identification is about the comparison of the palmprint against templates corresponding to all users in the database.

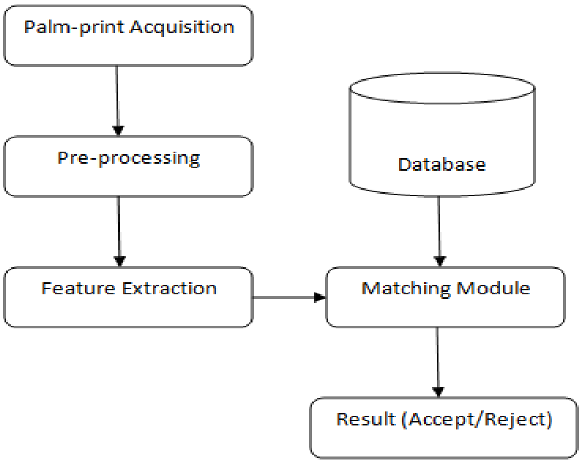


Fig -3: Palmprint verification system

A typical palmprint identification system is shown in fig - 3 which consists of four steps i.e., Palmprint acquisition, preprocessing, feature extraction, and Matching [1].

1.1 Palmprint Acquisition

Palmprint images are captured with the help of devices like camera or scanner. This will provide digital scanned images of palm of users. To scan the palms several devices are available in market, few examples are CCD-based scanners, digital scanners, video camera etc. A CCD-based scanner provides high resolution images and it accurately aligns the palms because the scanners have pegs for guiding the placement of hands while digital scanners provides low resolution images and takes large time for scanning. Fig -4 demonstrates one of the palmprint images from Hong Kong Polytechnic University captured using CCD.

Fig -4: CCD-based palmprint scanner

1.2Pre-Processing

In pre-processing, the desired part is selected of the scanned palm image and the unwanted part is removed also improve the resolution, to extract more accurate features. This process segments the center for feature extraction and set up a coordinate system. Pre-processing [3] consists of five steps, 1) binarize the images, 2) boundary extraction, 3) detecting the key points, 4) establish a coordination system and 5) extracting the central part. So basically Pre-processing works in two steps which is as follows:

i. Alignment of Image: palm edges are extracted and background of scanned palm image is removed in this step.
ii. Selection of Region of interest (ROI): In this, ROI is selected or cropped. ROI is actually the palm print image from the whole hand image.

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1.3 Feature Extraction

After the segmentation of central part, features can be extracted for matching. Feature extraction is performed on ROI of palm. Various features are extracted such as color of palm, clarity of lines, their intensity, position, length, and thickness of various lines, etc. In short this step extracts the compact representation of the particular palm image. These features are then stored in a system database to create a master template. A matching score is obtained by matching the identification template with the master templates stored in the system database. If the score is less than a given threshold, the user is authenticated. Several feature extraction methods are available to extract the features of palm.

1.4 Matching

Finally, matching is performed on a palm print database for verification of users. In this, current palm input is compared with templates stored in a database on the basis of some threshold. If both satisfy the threshold, then input is verified means authentication is done successfully. Otherwise, this new palm image is stored as a new template is a database.

The process to accept/ reject the user is performed on the basis of the matching algorithm. This matching is performed on the basis of the extracted features. Classification is the basis for the palm images to be accepted or rejected. Same type of samples is grouped in the same class. Some of the similar measures are Mahalanobis, Euclidean and Manhattan distances. Another classification approach path is the construction of decision boundaries. This may be achieved by the use of techniques such as Artificial Neural Networks (ANN).

1.5 Performance Metrics:

The following parameters are considered to measure the performance of palmprint based biometric systems:
i. False acceptance rate (FAR): It is the ratio of the number of unauthorized users accepted by the biometric system to the total of identification attempts made.
ii. False rejection rate (FRR): FRR is the ratio of the number of the number of authorized users rejected by the biometric system to the total number of attempts made.
iii. Equal-Error-Rate (EER): It is defined as the rate at which the FAR is equal to the FRR. In a top security system (e.g. an airport, bank) the FAR value must be minimum or zero, which might lead to a high FRR value.

II. PALMPRINT IDENTIFICATION TECHNIQUES

There are various techniques for palmprint identification has been proposed by many researchers. This survey is based on several palmprint identification techniques.

2.1 Palmprint identification with Fisherpalm

Another palmprint recognition method called fisherpalms is used by X.Q. Wu, D. Zhang, K. Wang in [3]. The points in the high dimensional image space are considered as the palmprint images in this method. To design palmprint from this high dimensional space to a lower dimensional feature space, a linear projection based on FLD (Fisher's linear discriminant) is used and different palmprints are separate in an efficient manner. The points in the high dimensional image space are considered as original palmprint space (OPS). There are two stages given by this method are Enrolment stage and Recognition stage. In the first stage, by the use of training samples the Fisherpalms linear transformation is computed and at first it is saved as Fisherpalm space and the mean of the palmprint classes is projected to Fisherpalm space. In the later stage, by projecting the input palmprint image onto the stored Fisherpalm space the feature vector is calculated. Obtained feature vector is now compared with the stored templates to produce the recognition result.

2.2 Using 2-D Gabor filter

Among the several palmprint identification methods one method is 2-D Gabor filter is used by Kong et al [4]. In this method 2-D Gabor filter is used to extract the texture information. In this, the Gabor function having certain parameters is used and that is converted into discrete Gabor filter. Gabor filter becomes to zero DC, for providing robustness to brightness. This adjusted Gabor filter is involved with sub images. By using certain inequalities sample points in the filtered image are coded into two bits. Only the phase information about the palmprint image is stored in feature vector by the use of coding method. The hamming distance is used to compare the two palmprint images in the matching process. In this each feature is treated as two 2-D feature matrices that are real and imaginary. To match the palmprint a normalized hamming distance is used. Hamming distance is zero, for perfect matching. It gives validity against variable brightness and contrast for images. However, it has limitation in the selectivity of orientation and major principal lines and wrinkles representation in the palmprint.

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2.3 Using Eigenpalm features

One of the palmprint recognition method used in [5] is based on Eigen space technology. In this method, the original palmprint images are converted into "eigenpalms" using Karhunen-Loeve (K-L) transform which is nothing but a small set of characteristic feature image. The Eigen vectors of the training set are called as Eigen palms. The Eigen vectors of the covariance matrix which contains the set of palmprint images are normally represented by K-L transform. Eigenvectors can be defined as the subspace of the palmprint, which are pertained to as eigenpalms. Each training set comprises of different palmprints, in which each palmprint is represented by an eigenvector. Due to that, the number of eigenpalms is equal to the number of different samples in the training set. As per the theory of Principal Component Analysis (PCA), it is not mandatory to select eigenvectors as base vectors. Only those eigenvectors that corresponds to the largest Eigen values may be used to interpret the characteristics of the set. In the form of Eigen values features are extracted and then Euclidean distance classifier is used for palmprint recognition.

2.4 Using Gabor feature based (2D)2 PCA

According to the previous works, Gabor filter involved with palmprint images were used to extract the features. The features were represented by the use of hamming code and identification is done using hamming distance method. It has various advantages, but it demands more time and memory for feature coding and to match the pixels. A series of Gabor filters of several scales and orientations (Gabor filter bank) are used to extract more local features, but it is hard to implement. By adding the above two processes a new algorithm came into the existence in [6]. In new process in the first step Gabor filter bank is used to extract the Gabor features by convolution with the original image. Gabor feature space contains all the Gabor feature metrics of the training samples. In the later step, the dimension of Gabor feature space is decreased in both row and column direction and (2D)2 PCA is used. This results in fewer coefficients for feature matching. In the final step Euclidean distance are used to perform feature matching and nearest neighbor classifier respectively are used for classification.

2.5 Using Gabor-based local invariant features

X.Pan et. al., in [7] proposed another feature extraction process. Typical palmprint recognition system consists of three phases such as preprocessing, feature extraction and identification. Features are extracted in feature extraction phase. Three steps are basically used to extract the features. A 2D Gabor filter is used in the first step. To extract local invariant features by convolution with the palmprint image, Gabor filter is used. During the next step, the received feature is provided to the two layer partition. Each palmprint image is separated into upper-layer blocks in the first partition. In the second partition each of the upper-layer blocks is separated into four and comprises of the lower layer partition. The local relative variance of the partitions is calculated in the final stage. At first local invariant feature is segmented and then the deviation of variances between these partitions that is lower-layer and upper layer is calculated to obtain the local invariant feature. Nearest neighbor classifier is used for matching.

2.6 Using Binary orientation co-occurrence vector

Basically for palmprint verification several methods have been used. Amongst all the most commonly used method is orientation based coding methods. In the orientation based coding method, dissimilar types of codes are present like competitive code (comp-Code) [8] and robust line orientation code (RLOC) [9]. Here dominant orientations are decided based on some criterion and the images are involved with filters of different orientations. By the use of simple coding the orientation map of palmprint high accuracy palmprint identification could be implemented. As only one dominant orientation is used to represent a local region so by doing this some worthful information will be lost. Multiple orientations are used to represent the local region, in [10]. By maintaining all orientation information this multiple orientation is achieved. This saving is done by adding the responses as a vector. Then in order to binarize the response vector thresholding is done. For identification purpose hamming distance is used.

2.7 Using 2-D Gabor wavelet

Palmprint image were taken as input in [12]. The palmprint image is normalized based on its orientation, position and clarification. The feature extraction step is done in two steps. In the first step, the image is decomposed using a 2D Gabor wavelet means by convoluting the image with the Gabor function. This decomposed image is provided to the next step that is in feature extraction step. Pulse Coupled Neural Network (PCNN) is used in the second step. PCNN transforms each of the decomposed sub band into a serial of binary images. From these binary images, entropy value is determined and considered as the feature. These features are used by support vector machine for the purpose of palmprint classification.

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2.8 Using adaptive lifting wavelet approach

The former work exercised on the palmprint identification took a lot of time and it was hard to implement with hardware. So, in order to overcome this problem wavelet based method is used in feature extraction step. In this method [11] basically three steps are used. Adaptive lifting approach and PCNN are used to extract the features and support vector machine is used for the identification purpose. In the first step, is used. To build new, possibly nonlinear, wavelets from existing ones the adaptive lifting wavelet scheme provides a simple yet flexible method. It contains a given wavelet transform that followed by an update and a prediction step. Each image decomposes into estimate image and detail image uses a wavelet transform. The output contains three detail sub bands and one estimate sub band. The detailed sub band is provided to the PCNN. In this each sub band is converts into a serial of binary images. Entropy values are calculated from these serial of binary images and reckoned as features. These features are provided to the classifier. Support vector machine analyzes data and recognizes patterns.

Table -1: Summary of Palmprint Identification

Method	**Feature**	**Classifier**	**Data Set**	**Accuracy (%)**
FDA	Fisher palm	L1	900	95.2
Gabor	Phase information	Hamming Distance	4647	97.59
PCA	Eigen palm	L1	900	92.4
GB(2D)2LDA	Gabor feature vector	Nearest neighbour	7752	99
Log Gabor	Training vector	Probabilistic neural network	80	92.5
BOCV	Binary feature	Hamming Distance	7752	98.3
Palm Code	Feature vectors	Hamming Distance	800	97.50
Wavelet Transform	Wavelet energy features	Neural network	1000	98

III. CONCLUSION

In this paper various existing methods have been reviewed for palmprint identification. Each technique has its own advantage and disadvantage based on cost, classification time and robustness to varying factors. The techniques can be selected based on the requirement. Palm identification is considered the most authentic technique because of its low cost, user friendly, high speed and accuracy. The objective is to work on the palmprint identification system is to develop a biometric system with increased speed and more accuracy. Palm print acquisition using CCD based scanner and Palm code, fusion code, competitive code and the theory of coding method are recommended. The future work can be extended to apply gaussianization, the feature normalization method on the high resolution images where multiple features can be extracted.

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