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A Review on Palm Print Verification System

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Abstract: Palm Print is one of the relatively new physiological biometrics, attracted the researchers due to its stable and unique characteristics. The rich feature information of palm print offers one of the powerful means in personal recognition. Palm print verification System has long been used and it was found that many research activities were carried out. This paper discusses about the number of research works introduced to overcome the difficulties faced in each stage of palm print verification. Our study on palm print recognition focuses on verifying the palm print in four different stages: Palm print acquisition, Preprocessing, Feature extraction and Palm print matching.

Keywords: Biometrics, Feature extraction, Palm print verification, Palm lines, Palm print matching.

1. Introduction

Biometric is the science of measuring human's characteristics for the purpose of authenticating or identifying the identity of an individual based on specific physiological or behavioral characteristics [1]. Several types of physiological characteristics used in biometric are appearance of face, hand geometry, fingerprint, iris and palm print.

The most widely used biometric feature is the finger print and the most reliable feature is the iris. However it is very difficult to extract small unique features such as minutiae from unclear finger prints and the iris input devices are very expensive. Other biometric features such as the face and voice are less accurate and they can be mimicked easily. The palmprint is a relatively new biometric feature, has several advantages compared with currently available features [1]. The seven factors affect the determination of a biometric identifier in a particular application: universality, uniqueness, Permanence, collectability, performance, acceptability and circumvention as shown in table 1. Palm print recognition has been introduced a decade ago. It has gradually attracted the attention of various researchers due to its richness in amount of features. Palm is the inner surface of the hand between the wrist and the fingers. The Palm area contains a large number of features shown in Fig.1 that can be used as biometric features such as Principal lines, geometry, wrinkle, delta point, minutiae, datum point features and texture [2]. The principle lines are also called as flexion creases. The formation of these lines is related to the finger movements, tissue structures and the purpose of skin. Even the palm prints of identical twins are different [4]. This is because the genetic code in the DNA gives general instructions on the way skin should form in a developing fetus but the specific way it forms is a result of random events position of fetus in the womb at a particular moment and the exact composition and density of surroundings amniotic fluid.

Palm print verification employs either high or low resolution images. Most of the research on palm print verification uses the low resolution images [3]. The palm print Verification system consists of four stages: Palm print image acquisition, Preprocessing, Feature extraction and matching as shown in Fig.2. The palmprint image is acquired using a palm print scanner .Preprocessing has two parts, image alignment and region of interest selection. Image alignment is done by referring to the key points. Region of Interest selection is the cropping of palmprint image from the hand image .Feature extraction obtains discriminating features from the preprocessed palmprints .The matching compares the captured image features with the stored templates.

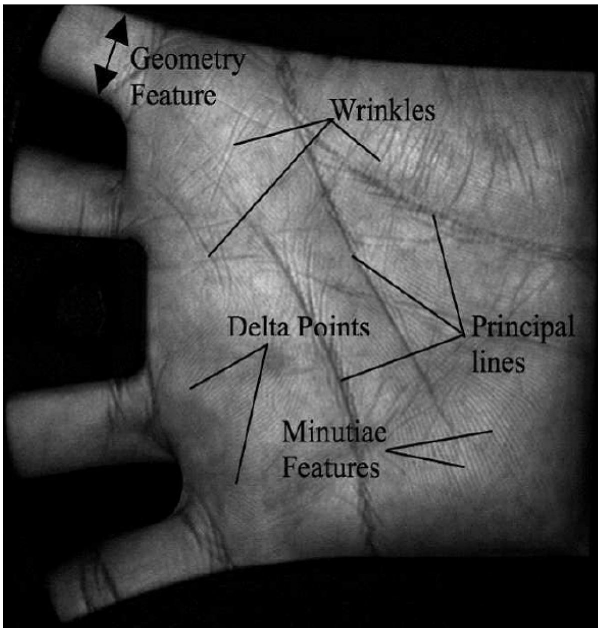

Fig. 1 Different Features of Palm.

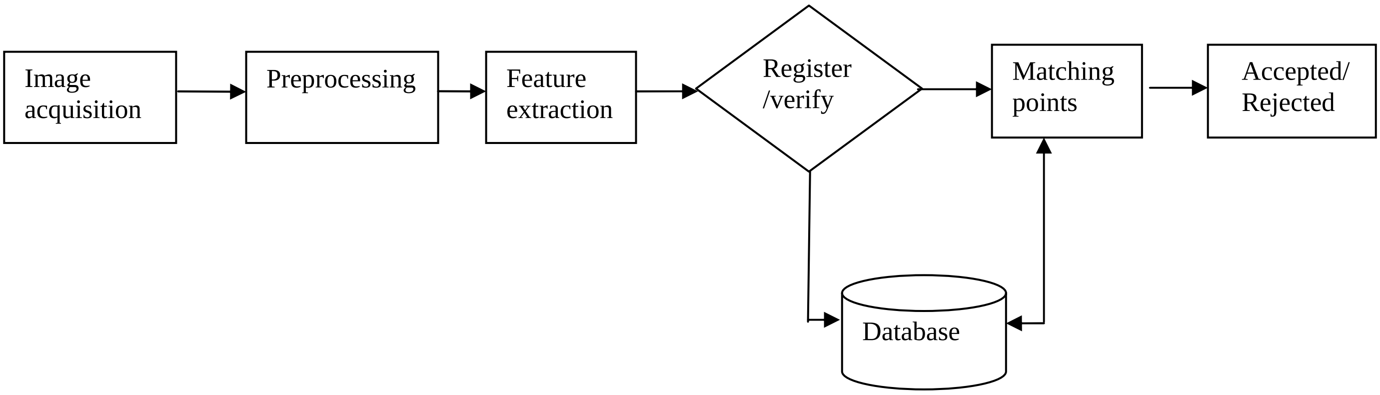

Fig. 2 Stages in Palm print Verification

Biometric identifier	Universality	Distinctiveness	Permanence	Collectability	Performance	Acceptability	Circumvention
DNA	H	H	H	L	H	L	L
Ear	M	M	H	M	M	H	M
Face	H	L	M	H	L	H	H
Facial thermogram	H	H	L	H	M	H	L
Fingerprint	M	H	H	M	H	M	M
Gait	M	L	L	H	L	H	M
Hand geometry	M	M	M	H	M	M	M
Hand vein	M	M	M	M	M	M	L
Iris	H	H	H	M	H	L	L
Keystroke	L	L	L	M	L	M	M
Odor	H	H	H	L	L	M	L
Palmprint	M	H	H	M	H	M	M
Retina	H	H	M	L	H	L	L
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H

Table 1. Comparison of Biometric traits (High, Medium & Low are denoted by H, M, L respectively)

The rest of this paper is organized as follows: Section 2 reviews palm print acquisition devices, Section 3 summarizes the preprocessing algorithms, Section 4 discusses the feature extraction and matching methods, Section 5 lists various fusion approaches and section 6 offers conclusion.

2. Palm Print Acquisition

Palm print can be captured by widely used CCD based palmprint scanners, video cameras, Digital cameras and Digital Scanner. The Fig. 3 Shows a CCD based palmprint scanner which attracts the most of the researchers for acquiring the image because the scanner have pegs for guiding the placement of hands [3], [5]. CCD camera consists of a set of optical components work together to obtain the data from the palm. However, the quality of the Palm print image depends highly on the camera technology used. Zhang et al. designed the world's first online palmprint capture devise at Hong Kong Polytechnic University [2], [50]. Palm print image is taken either in pegged or peg less environment. The digital scanner can acquire high resolution hand image but requires more time to scan which are not suitable for real time application.

Digital and video cameras can also be used to collect palmprint images and these images might cause recognition problem as their quality is low because they collect image in an uncontrolled environment [21] with illumination variations and distortions due to hand movement. Fig 4 shows an image collected by CCD scanner and digital camera.

3. Preprocessing

Preprocessing is used to correct distortions, align different palmprints, and to crop the region of interest for feature extraction. Research on preprocessing commonly focuses on five steps 1.Binarizing the palm images 2.Boundary tracking 3.Identification of key points 4.Establishing a coordination system and 5.Extracting the central part.

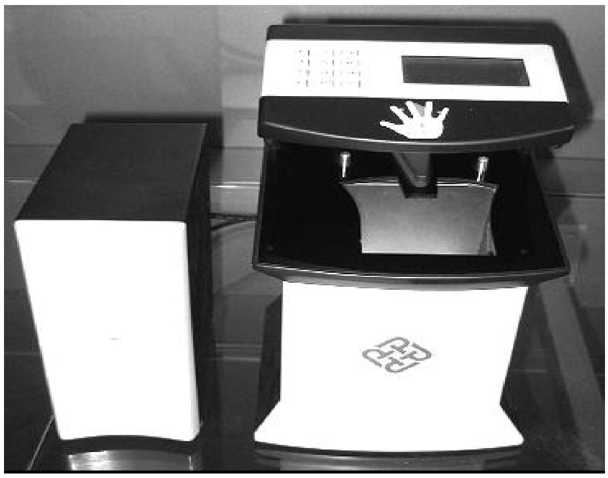

Fig. 3 CCD Based Scanner

Most of the research uses Otsu's method for binarizing the hand image [32]. Otsu's method calculates the suitable global threshold value for every hand image. According to the variances between two classes one of the classes is the background while the other one is the hand image. The boundary pixels of the hand image are traced using boundary tracking algorithm [21]. The key points between fingers are detected using several different implementations including tangent [5], Bisector [13], [28] and Finger based [7], [8].

The tangent based approach considers the edges of two fingers holes on the binary image which are to be traced and the common tangent of two fingers holes is found to be axis X. The middle point of the two tangent points is defined as the key points for establishing the co-ordinate system [5].

Bisector based approach concentrates on not joining the fingers by converting the upper region of the fingers and the lower part of the image to white. It aims in determining two centroids of each finger gaps for the image alignment since only the centre of gravities within the defined three finger gap region. After locating the three finger gaps the centre of gravity of the gaps can be determined. Then the two centroids of each finger gap are connected to obtain the three lines. The line drawn through the centroids of each finger gap region intersects the palm of a key point.

Han and his team propose two approaches to establish the co-ordinate system, the first approach based on the middle [8] and the other based on the point, middle and ring finger [7].

After establishing the co-ordinate systems, the central part of the palm prints are segmented using three classes: Square based segmentation, Circle based segmentation and Elliptical based segmentation. Among all these methods most of the researchers uses Square based method because it is easier for handling translation variation.

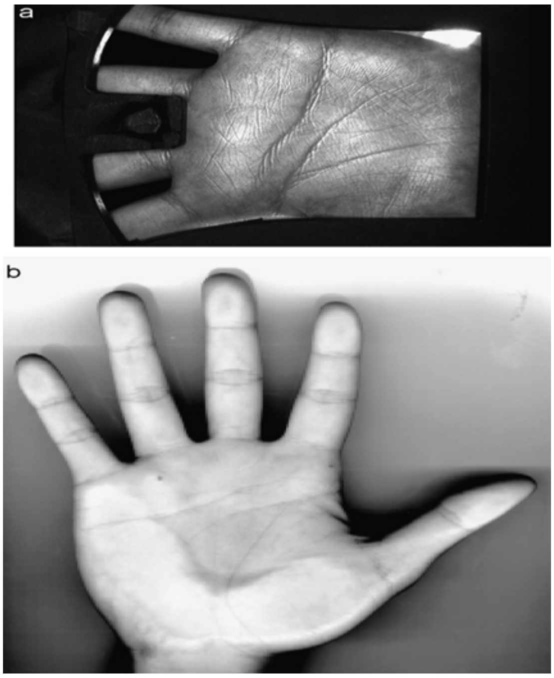

Fig. 4 Two palm print collected by a) CCD Scanner b) Digital camera

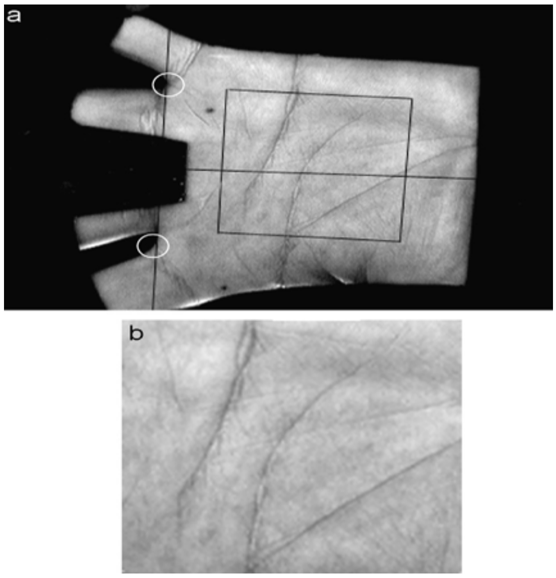

Fig. 5 (a) Key Points Identification (b) ROI Extraction

4. Feature Extractions and Matching

After preprocessing of palm print images features can be extracted for matches. There are two types of recognition algorithms, verification and identification. In verification, the system validates a person’s identity by comparing the captured biometric data with her own biometric templates stored in the system database. Verification is typically used for positive recognition, where the aim is to prevent multiple people from using the same identity. In identification, the system recognizes an individual by searching the templates of all the users in the database for a match. Verification algorithms must be accurate. Identification algorithms must be accurate and fast..Research on feature extraction and matching methods can be classified into 4 categories: Line-based, subspace-based, Statistical-based and coding based.

4.1 Line Based Approaches

The line-based approach either develop edge detectors or employ the existing edge detection methods to extract palm lines [16], [17], [19], [26], [31], [36], [37], [38], [46], [52]. The palm lines are either matched directly or represented in other format for matching [41], [42].

Wu et al. use sobel masks to compute the magnitude of the palm lines [19], [35]. The magnitude are projected along the x and y directions to form histograms. They designed two masks to compute the first order derivative and second order derivative of palm print images. The first order and second order derivatives can be obtained by rotating the two masks. The Zero crossing of the first order derivative is used to identify the edge points and corresponding directions. Second order derivative is used to identify the magnitude of the lines. The weighted some of the local directional magnitude is regarded as an element in the feature vector. Euclidian distance is used for matching [34].

Kumar et al. integrated line like feature and geometrical features for personal verification [53], [39].

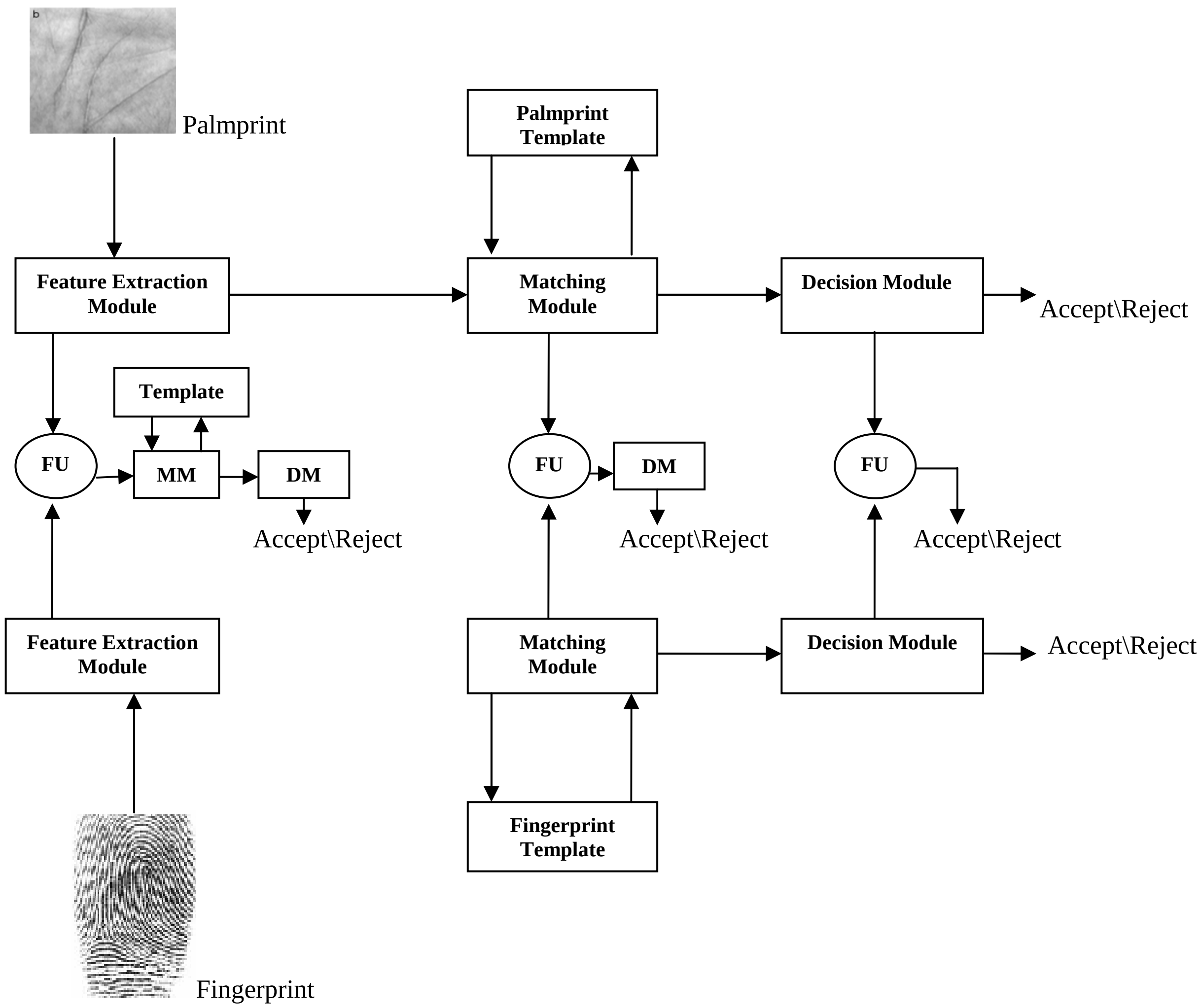

Fig. 6 Levels of fusion in a bimodal biometric system;

FU: Fusion Module, MM: Matching Module, DM: Decision Module.

Kung et al. formed a feature vector based on a low resolution edge map. The feature vector is passed into decision based neural networks [36].Han et al. used sobel and morphological operations to extract line like features from palm print images [7].

Huang et al. proposed a two-level modified finite radon transform and a dynamic threshold to extract major wrinkles and principal lines. Two binary edge maps are compared based on pixel-to-area comparison [46].

4.2 Subspace Based Approaches

Sub space based method is also called appearance based approach, generally involve principal component analysis (PCA), Linear discriminant analysis (LDA) and independent component analysis (ICA).The subspace coefficient are considered as features .In addition to applying PCA, LDA and ICA directly to palm print images, researchers also employ wavelets, Discrete cosine transform and kernel in their method [6], [9], [10], [11], [14], [20], [24], [15].

Dale et al. proposed discrete cosine transform (DCT) based feature vector for palmprint representation and matching compared with DFT and wavelet transform [5].

Laadjel et al. approach combines fisher's linear discriminant (FLD) and Gabor Wavelet responses. This method involves convolving a palmprint image with a series of Gabor wavelets at different scales and rotations before extracting features from the Gabor filtered image [4].

4.3 Statistical Approaches

Statistical approaches are categorized into local and global statistical approaches. Local Statistical approaches transforms images into another domain and divide the transform into several small regions. Local statistics such as means and variances of each small region are calculated and regarded as features [8], [12], [18], [27], [29], [40].

Yong et al. method for feature extraction divides the palm print image into a set of n small regions and then calculates the mean and S.D of sub regions. Euclidian square norm is employed for matching [10].

Researchers compute global statistical features like moments, centre of gravity and density directly from the whole transformed images [9], [32].

4.4 Coding Approaches

Coding approaches encode the filter coefficient as feature using Gabor filters [43], [47]. Daugman, the inventor of Iris code, has demonstrated that the bitwise hamming distance allows real-time brute force identification in large databases.

Palm code uses a single Gabor filter to extract the local phase information of palm print [2], [5], [40],[48]. D.Zhang et al. uses the first version of fusion code to avoid correlation that results from palm code. It involves the use of four directional Gabor filters to generate four palm codes and these palm codes are combined [22].

In the second version of fusion code, D.Zhang et al. identified that the optimal number of Gabor filter is two. The second version of fusion code is much more effective than the first.

Palm code and fusion code employ quantized phases as features and the hamming distances as matches. The first version of competitive coding scheme uses multiple two dimensional Gabor filters to extract orientation information from palm lines. This information is then stored in a feature vector called the competitive code. The angular distance is used for comparing two codes [54].

In second version of competitive code, 25 translated templates are generated from an input palm print to match the template in a database [4].

Kong et al. introduced a fusion code method to encode the phase of the filter responses from a bank of Gabor filters with different orientation. Kong et al. developed a competitive code method to encode the orientation information and achieve the state -of –the –art palm print Verification accuracy [54].

Wu et al. modified fusion code to extract the orientation field and uses the hamming distance for matching [35], [43].

Some approaches combine several image processing methods to extract palmprint features and employ some standard classifiers such as Neural networks to make the final decisions [25],[49],[51],[33].

Yue et al. proposed a modified fuzzy c-means cluster algorithms to determine the orientation of filters .This achieves higher verification accuracy [26].

Zu et al. use probability feature image (PFI) in order to suppress random noises in feature image and fuzzy logic was employed in matching algorithm [6].

Chen et al. [44], [55] perform a two dimensional dual tree complex transform on the preprocessed a palmprints to decompose the images. Dual –tree complex transforms are proposed to resolve the weakness of traditional wavelet transform which is not shift –invariant, for pattern recognition. Then they apply Fourier transform on each sub band and regard the spectrum magnitude as features. Finally, SVM is used as a classifier.

Hennini-Yeamans et al. employ log –Gabor filters to assign line content scores to different regions of palm prints [25]. A Specific number of regions with top line –content scores are selected to train correlation filters. They use optimal tradeoff synthetic discriminant function (OTSDF) filter as a classifier.

5. Fusion

Fusion of multiple traits of an individual can improve the matching accuracy of a biometric system. Some of the limitations such as noisy data, intra-class variations, spoof attacks and unacceptable error rates of a unibiometric system can be addressed by designing a system that consolidates multiple sources of biometric information. Multimodal biometric systems are those which utilize, or are capability of utilizing, more than one physiological or behavioral characteristic for enrollment, verification, or identification. The multimodal biometrics has drawn more and more attention in recent years due to its promising applications and theoretical challenges [1].

5.1 Levels of fusion

Based on the type of information available in a certain module, different levels of fusion can be defined as shown in fig 6. (a) Fusion at the data or feature level: Either the data itself or the feature sets originating from multiple sensors/sources are fused. (b) Fusion at the match score level: The scores generated by multiple classifiers pertaining to different modalities are combined. (c) Fusion at the decision level: The final output of multiple classifiers is combined.

Biometric systems that integrate information at an early stage of processing are believed to be more effective than those systems which perform integration at a later stage. Since the feature set contains richer information about the input biometric data than the matching score or the output decision of a matcher, fusion at the feature level is expected to provide better recognition results. However, fusion at this level is difficult to achieve in practice because (i) the feature sets of the various modalities may not be compatible (e.g., eigen-coefficients of face and minutiae set of finger), and (ii) most commercial biometric systems do not provide access to the feature sets (nor the raw data) which they use in their products. Fusion at the decision level is considered to be rigid due to the availability of limited information. Thus, fusion at the match score level is usually preferred, as it is relatively easy to access and combine the scores presented by the different modalities.

Many biometric traits including fingerprint [56], palmvein [57], finger surface [58],[59],[60], face [61],[62],[63],[64], iris [65] and hand shape [66],[67],[68],[69],[70] have been combined with palmprints at score level or at representation level. Although fusion increases accuracy, it generally increases computational costs and template sizes.

6. Conclusion

In this paper we have reviewed the various existing methods used for palm print verification system.

We recommend D.Zhang et al. work [5] for palm print acquisition which uses CCD based scanner. We also recommend Kong's PhD thesis because it contains palm code, fusion code, competitive code and the theory of coding method. We suggest Adams Kong et al. competitive coding scheme for palm print verification [54].Palm print recognition is an emerging field and only limited works were carried out which paves way for the researchers to invent new methods to reduce the error rates and to improve the accuracy and speed of the system.

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