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A Study on Various Palmprint Recognition Methods

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Abstract: *In the biometric personal identification, the palm print based recognition systems have become one of the active research topics in recent years. The identification process consists of image acquisition, pre-processing, feature extraction and matching with the database. Palm print recognition, being one of the extensively used biometric recognition system, there are many methods and algorithms available to implement it. An extensive survey listing the benefits and deficits in the established methods would give a clear and concise idea of the method to be approached for building a system that is more efficient and which overcomes major faults present in the systems. This survey report gives the general view of the concept of the four different approaches used to implement various palm print recognition methods and the comparative conclusions of the methods are also presented. The four approaches considered are line based method, representation based method, SIFT based method and PCF based method.*

Keywords— *Palmprint Recognition, Biometrics, PCF, SIFT, RLOC Matching, Preprocessing, IFFT.*

1. Introduction

Biometric based recognition is becoming popular and getting more acceptance in our information society. Biometrics uses a variety of techniques for identifying a person based on certain physiological or behavioral attributes. These attributes include fingerprint, facial features, retina and iris patterns, speech patterns, palmprint etc. Palmprint recognition is an important personal identification technology and it has attracted wider attention. The palmprint consists not only principle curves and wrinkles but also rich texture and miniscule points, so the palmprint identification is able to achieve a high accuracy because of the availability of rich information in palmprint. Palmprint based biometric method has gained high impact over the other biometric methods due to its ease of acquisition, reliability and high user acceptance. Multiple feature extraction from image results in higher accuracy of the authentication system. Biometric is one of the most secure and convenient authentication tool. Biometric based identification systems are becoming popular in the field of personal identification/verification over the past decade. Based on the traits used for identification, biometrics is broadly classified into two types such as behavioral and physiological as shown below in Figure1.

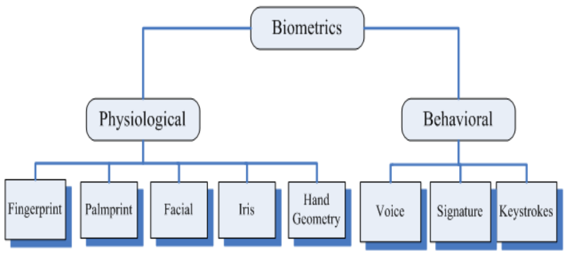

Figure 1. Classification of biometric features.

In biometric system, physiological characteristics/traits are found to be more reliable compared to the behavioural characteristics. Palm print here comes under the physiological category, it refers to an image acquired from the palm region of the hand. Palmprint focuses on the inner surface of a hand, the shape of the surface and the pattern they form. Palmprint contains more amounts of detail in terms of principal lines, wrinkles, creases and epidermal ridges. The inner surface of the palm print mainly contains three flexion creases, secondary creases and ridges. The flexion creases are also called as principal lines and the secondary creases are called wrinkles.

Building a palmprint recognition system usually involves four modules: image acquisition, pre-processing, feature extraction, and matching. In image acquisition, research teams have independently developed several CCD-based palmprint capture. Several public image databases have recently been made available to facilitate the development of palmprint recognition technology. In pre-processing, the aim is to detect several key points (usually two or more) to position different palmprint images and establish a reference coordinate system. According to the reference coordinate system, the central parts of palmprint images are segmented for subsequent feature extraction and matching. Rather than detecting the key points, other methods include fitting an ellipse of the palmprint region, and then establishing the reference coordinate system in accordance with the orientation of the ellipse. In feature extraction and matching, a set of discriminative features is extracted from a palmprint image, and then compared against the stored palm images to generate matching results. Feature extraction and matching are two of the most crucial problems in palmprint recognition, and have attracted researchers with different applications, such as biometrics, pattern recognition, computer vision, and neural networks. Due to this fact, feature extraction and matching methods are much more diverse than pre-processing methods.

2. Palmprint Recogmition Methods

In this section, a survey of these four categories of palmprint recognition approaches is given in detail. More other approaches are also under study and research .The related and wide study in this area may result in the development of more efficient and cost effective hand based identification systems. Also, it will be a great leap in the area of biometrics based identification systems for personal identification. A thorough reference on various related works and papers are performed to get more knowledge. Also, a comparative study is done to identify the best palmprint recognition methods which can be used in future implementation of such systems. From the survey and reference to various scientific papers and articles, the detailed explanation of four methods are given below and in the rest of the paper.This paper provides an extensive survey and comparison of various palmprint recognition methods.Building a palmprint recognition system usually involves four modules: image acquisition, preprocessing, feature extraction, and matching. With increasing interest in palmprint recognition, researchers have proposed a variety of palmprint feature recognition approaches, like line-based method, representation –based method, SIFT based methods, PCF based recognition method and so on.

2.1. Line Based Method

Lines are the basic feature of palmprint and line based methods play an important role in palmprint verification and identification. Line based methods use lines or edge detectors to extract the palmprint lines and then use them to perform palmprint verification and identification. In general, most palms have three principal lines: the heartline, headline, and lifeline, which are the longest and widest lines in the palmprint image and have form line shapes and positions. Thus, the principal line based method is able to provide stable performance for palmprint verification.Palmprint principal lines can be extracted by using the Gobor filter, Sobel operation, or morphological operation. The pixel-to-area matching strategy is adopted for principal lines matching in Robust Line Orientation Code (RLOC) method , which defines a principal lines matching score and the query palmprint can be classified into the class that produces the maximum matching score. In linebased method, the discriminative Palmprint features were extracted from a pre-processed acquired images using easily available and low cost camera. Distances from endpoints to endpoints and point of interception to endpoints were calculated and final matching is found out. Hand images were acquired in RGB colour space and segmented from the background. The principal lines were extracted and the technique is used to characterize the extracted principal line which has been used in the formation of the feature vector. The flow diagram of line based palmprint recognition process is shown in Figure.2 and is shortly followed by detailed discussion.

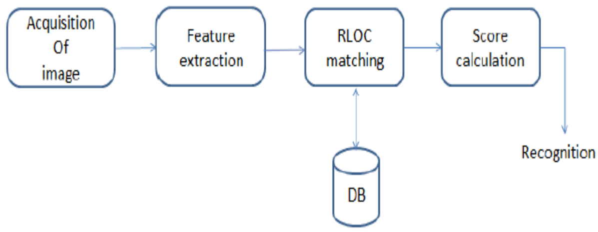

Figure 2. Line Based Method.

2.1.1. Image Acquisition and Preprocessing

Hand images were acquired using a low resolution camera in a contactless unconstrained position and environment. The acquired Red-Green-Blue (RGB) hand images were converted to YCbCr colour space using the standard conversion equation. The chromatic blue (Cb) and chromatic red (Cr) channel of the transformed image f_t is then passed through a developed artificial neural network (ANN) based Finite Impulse Response (FIR) filter to separate the skin and non pixels of the image. After successful preprocessing, the region of interest (ROI) is extracted manually from the segmented hand image.

2.1.2. Feature Extraction

Detection of palm lines is basically an edge identification issue. Edges are visualized due to the gradient change in intensity. Thus, the sobel edge detector was employed in two directions 0degree and 90 degree. The directional sobel mask is used for this. Thus, for an input gray image (ROI) f(x,y), a vector derivative is generated as gradient and the magnitude of the gradient is then calculated using the respective equations[1].

2.1.3. RLOC Matching

The pixel-to-area matching strategy is adopted for principal lines matching in Robust Line Orientation Code (RLOC) method , which defines a principal lines matching score as follows:

$$S(A,B)=\Sigma\Sigma A(i,j) \text{ AND}(-B(i,j))$$

where A and B are two palmprint principal lines images, represents the logical AND operation, NA is the number of pixel points of A, and B (i, j) represents a neighbor area of B(i, j). For example, -B (i, j)can be defined as a set of five pixel points, B(i 1, j), B(i +1, j), B(i, j), B(i, j 1), and B(i, j +1). The value of A(i, j),B(i, j) will be 1 if A(i, j) and at least one of .B (i, j) are simultaneously principal lines points, otherwise, the value of A(i, j) B (i, j) is 0. S(A, B) is between 0 and 1, and the larger the matching score is, the more similar A and B are. Thus, the query palmprint can be classified into the class that produces the maximum matching score.

2.2. Representation Based Method

In representation based method, a palmprint recognition method based on a two-phase test sample sparse representation is performed on palmprint images [2]. In the first phase, a test sample is represented as a linear combination of all the training samples and m nearest neighbors are selected based on the representation ability. In the second phase, the test sample is represented as a linear combination of the determined m nearest neighbors and the representation result is used for classification. The flow diagram for TPTSSR is given below in Fig 3. Assume that there are c classes and n training samples: xi, (i=1,2,..,n). If a training sample is from the *k* th class (k=1,2,..,c), *k* will be taken as the class label.

2.2.1. Phase 1

In Phase 1, m nearest neighbors of the test sample will be identified from the whole training set. For a given test sample, Y , it could be expressed as: Y = XA where A,X and Y are all column vectors. As X is a singular square matrix usually, we can solve A by using:

$$A= (X^T X + uI)^{-1} X^T Y$$

where u is a small positive constant and I is an identity matrix.

A distance between the test sample and the *i* th training sample is defined as:

$$e_i = \textit{square of} \parallel Y - a_i x_i \parallel$$

It can be viewed as a measurement of the distance between the test sample and ith training sample. A small ei means that the ith training sample has a great contribution to the representation of the test sample. Thus, e_i is used to identify the m training sample, *xi* : i= [1……m] , with the biggest contribution.

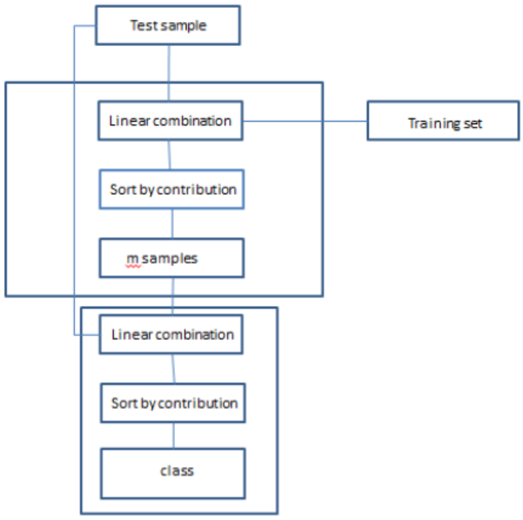

Figure 2. Representation Based Method.

2.2.2. Phase 2

The second phase is to represent the test sample as a linear combination of the selected m training samples, xi: i=[1…..m] and to classify the test sample by the representation results[2]. Similar steps are repeated as phase one with the obtained linear combination of test samples.As the m neighbors might be from different classes, we calculate the sum of the contribution to represent the test sample of the neighbors from each class. The sum value is used to classify the test sample finally.Suppose all neighbors from class k are xi(k),then deviation is calculated using euclidean distance formula between test sample and linear combination of images in same class. A smaller deviation means a greater contribution to the representation of the test sample. Finally, y is classified as the jth class with minimum deviation samples with respect to test sample.

2.3. SIFT Based Method

SIFT means Scale Invariant Feature Transform [3]. SIFT features are based on local information, which are invariant to image shift, scale, and rotation variations, and partially invariant to illumination and projective changes. Thus, it is more stable than principle lines for image alignment and can also align images with affine and projective variations. The flow diagram is shown in Fig 4.

2.3.1. Image acquisition and preprocessing

The palmprint images are captured using low resolution capturing devices Sufficient amount and more stable matched SIFT feature points will lead to a more precise solution of the image transformation model. The aim of preprocessing is to enhance palmprint images to improve the quantity and stableness of SIFT feature points. The circular Gabor filter is employed for palmprint image preprocessing.

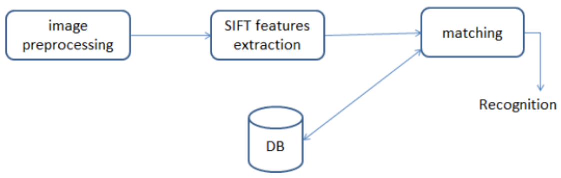

Figure 4. SIFT Based Method.

2.3.2. SIFT features extraction and matching

a. Scale space construction

The Gaussian scale space is constructed through:

$$G(\sigma)=L(\sigma) * I$$

where $G(\sigma)$ is the Gaussian kernel with scale , and I is the enhanced palmprint image.

b. Key point localization

Key point localization is performed in the difference of Gaussian (DoG) images, which are obtained through subtraction of neighborhood planes of Gaussian scale space, as

$$D(\sigma) = (G(k\sigma) - (G(\sigma))I)$$

where k is the scale factor. The local extrema of DoG are detected as key point candidates by using non-maximum suppress in both spatial and scale spaces. After that, a detailed model is fit to determine the finer location of key points by using the quadratic Taylor expansion of $G(\sigma)$. The key point candidates are then refined by a threshold to dismiss unstable ones.

c. Orientation assignment

A local patch taking key point as the center is considered for orientation assignment. The phase and magnitude of pixel gradient in this area are calculated. A histogram of gradient (HOG) is computed, and the angle corresponding to the maximum bin is taken as the dominant orientation of that key point. With the dominant orientation, all the descriptors can be normalized to the same orientation, so that the orientation invariance is obtained.

d. Descriptor computation

The HOG of the local patch around a key point is taken as the descriptor in SIFT. Before the HOG is formed, angle normalization is performed according to the dominant orientation. Once the SIFT features are extracted from both gallery palmprint image and query palmprint image, the descriptors are matched using Euclidean distance.

2.4. PCF Based Recognition Method

Phase Correlation is a method to check the similarity of two images with equal size and similar features. It can be used for template matching, object tracking, motion estimation, etc Frequency-domain palmprint matching is based on the 2D Discrete Fourier Transform (2D DFT) property[4]. It consists of translational displacement in the spatial domain that corresponds to a linear phase shift in the frequency domain. To obtain the Phase Correlation of two images, perform these steps:

1. Load two images, f and g.
2. Perform FFT on each image, resulting in F and G.
3. Obtain the cross power spectrum using this formula:

$$R = F\bar{G}/|F\bar{G}| ,$$

where G is the complex conjugate of G.

4. Obtain the phase correlation by performing IFFT on R.

The result is a 2D array with each element has a value between 0 to 1. When the two images are similar, their PCF gives a distinct sharp peak. When the two images are not similar, the peak drops significantly. Thus, the PCF shows much discrimination capability than the ordinary correlation function. The height of the peak can be used as a good similarity measure for image matching. Phase correlation is an approach to estimate the relative translative offset between two similar images other data sets. It is commonly used in image registration and relies on a frequency-domain representation of the data, usually calculated and found by fast Fourier transforms. The term is applied particularly to a subset of cross-correlation techniques that isolate the phase information from the Fourier-space representation of the cross- correlogram.

3. Comparison

This section compares the various palmprint recognition methods based on the accuracy obtained in achieving efficient personal identification. The comparison based on features,techniques, FAR, FRR, accuracy is given in the table below.

Table 1. Comparison between features and techniques of various palmprint recognition methods.

Methods	Features	Techniques
Line Based Method	Principal Lines	Sobel Operation and RLOC
Representation Based Method	Full Palmprint Image	Linear Combination of Images
SIFT Based Method	SIFT Features	Euclidean Distance
PCF Recognition Method	Region of Interest	2D DFT

Table 2. Comparison between the FAR , FRR and accuracy of various palmprint recognition methods.

Methods	FAR	FRR	Accuracy
Line Based Method	0.68	0.59	98.37
Representation Based Method	0.03	0.16	98.92
SIFT Based Method	0.5	0.5	98.4
PCF Recognition Method	0.03	0.76	99.97

4. Conclusion

In this paper, firstly a brief description of four palmprint recognition methods is given. The wide and elaborative study on the topic helped in understanding the various algorithms used at each steps of line based method, representation based method, SIFT based method and PCF based method. A comparative study of these four methods on various aspects helped in understanding thoroughly about each of the methods. In the line based method, extraction and capturing of palmprint image features is easier. Representation based method is simple and intuitive, but it is little time consuming. In SIFT method, invariant features are used for palmprint recognition and also satisfactory verification accuracy is achieved. PCF method has high capacities to be used in the environments that require a high Security and it provides much more accuracy. At current status of biometrics evolution, enhanced results can be achieved by methods fusion and combined modality methods which can give better results over other approaches.

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