A HIGH RESOLUTION PALMPRINT IDENTIFICATION USING NOVEL RIDGE EXTRACTION AND MATCHING TECHNIQUES

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ABSTRACT

Palmprint has attracted the recent researchers and is mostly studied due of its reliability, stability, distinctiveness and environment flexibility. This trait is mostly used in forensic applications rather than commercial applications to identify an individual based on ridge features. Images used in forensic applications are high resolution latent images which are almost partial. Moreover, the time interval between the impression left on the surface and the scanning of the latent print by the forensic experts produces noise and distortion which is a challenging one for palmprint authentication system. This research paper describes the novel ridge based techniques to be used in the palm authentication system which is then compared with that of the existing method. An enhanced Gaussian filter is designed to recover the broken ridges interrupted by both relatively wide and small creases, which significantly improved the efficiency of ridge extraction algorithm. Moreover features such as ridge orientation and ridge frequency were extracted and matched. Experiments were carried out on public high-resolution palmprint database and the results proved the effectiveness of the proposed method.

Keywords: Palmprint, Ridges, Gaussian filter, Ridge orientation, Ridge frequency.

1. INTRODUCTION

An important challenge to the present security system is to identify an individual more precisely. Traditional used token-based or knowledge-based methods are easily compromised thus biometric fills the gap [1]. With the increasing usage of Information Technology in the field of banking, science, medicine, etc., there is an immense need to protect the systems and data from unauthorized users. The idea is that to use something that is not easily known by others. Biometrics is used for authenticating and authorizing a person. Human readable Identification methods like ID cards or documents offered no help when it came to user authentication on information systems [2].

Image authentication is used to verify or validate whether an image is authentic. It provides an agreement that there is no change to the original image and the test image and prevents forgery [3]. Nowadays manipulating digital images efficiently and seamlessly has become very easy with the availability of powerful software and necessary to ensure confidentiality as well as integrity of the images that are transmitted. A biometric system, essentially a pattern recognition system, designed and operated under two stages namely enrollment stage and recognition stage [4], is developed such that it automatically identifies an individual with the trait used.

Palmprint has recently attracted the researchers due to its abundant distinct features found on the surface of the palm, which leaves unchanged in individual life span. These include principal lines, wrinkles, and ridge-based features. Principal Line Features and wrinkles are not that much reliable like ridge-based features. Palm ridges which are used as a significant measurement are further classified as level 1, level 2 and level 3 features Level 1 features (Ridge features) comprise of ridge orientation and ridge density [5]. Level 2 are minutiae features and Level 3 includes pore, dot, short ridge, incipient ridge and other features.

This paper is aimed to deal with the effect of relative wide creases so the objective here is to design an enhanced Gaussian filter to recover the broken ridges interrupted by both relatively wide and small creases, which significantly improved the efficiency of ridge extraction algorithm. The rest of the paper is organized as follows: Section II, discusses the related existing works based on ridge features. Section III proposes the hybridization method. The databases used are presented in section IV. Performance metrics are presented in section V. The experimental results and analysis are discussed in section VI. Section VII Concludes the work of this paper.

2. LITERATURE REVIEW

This section presents the detailed survey of the existing ridge-based methods used in palmprint authentication systems.

Jifeng Dai, Jianjiang Feng [6] developed a novel palmprint recognition system. The main contributions were i) Statistics of major features of palmprints were quantitatively studied, ii)A segment based matching and fusion algorithm wa proposed to deal with skin distortion and varying discrimination power of different palmprint regions iii) To reduce the computational complexity, an orientation field-based registration algorithm was designed for registering the palmprints into the same coordinate system before matching and a cascade filter was built to reject the nonmated gallery palmprints in early stage. The proposed matcher was tested by matching 840 query palmprints against a gallery set of 13,736 palmprints. Experimental results showed that the proposed matcher worked well than the existing matchers both in matching accuracy and speed.

Jifeng Dai and Jie Zhou [7] proposed a novel recognition algorithm for high-resolution palmprint. The main contributions were 1) use of multiple features, namely, minutiae, density, orientation, and principal lines for palmprint recognition 2) Design of a quality-based and adaptive orientation field estimation algorithm in case of regions with a large number of creases. 3) Use of a novel fusion scheme for an identification application. Besides, the discriminative power of different feature combinations were analyzed and found that density was very useful for palmprint recognition.

Wanfeng Huang, Xirong Lin [8] proposed a palmprint matching method based on ridges' orientation and frequency information. With an optical acquisition device, high-resolution palmprint images were captured and employed in this palmprint verification approach. In preprocessing, palm type identification has been introduced to speed up feature extraction process. The proposed filter-based algorithm uses a bank of Gabor filters to capture both local and global details in a palmprint and represent the extracted features as different point sets. A congruent triangle method has been used to the alignment of point sets. Moreover, the match method is designed according to the character of the feature points .

Fanchang Hao, Lu Yans [9] proposed a general method to measure the image quality of a block or full image form forensic palmprints based on the ridge properties. Two new features namely ridge period and ridge orientation variance were proposed to measure the palmprint image quality. Some features like ridge orientation continuity, ridge thickness uniformity and ridge-valley contrast were also taken into account to enhance the classification performance. Then a supervised learning method was proposed to measure the quality of palmprint images. Labeled palmprint images were used to in training three different kind of existing classifiers and then used them to predict the quality of images. To show the reliability and stability of this method, cross-validation was used on multi- classifiers.

Rodrigo M. Barros, Bruna E.F. Faria [10] evaluated the morphometry of latent palmprint ridges, as a function of time, in order to identify an aging pattern. The latent marks were deposited by 20 donors on glass microscope slides considering pressure and contact angle, and then were maintained under controlled environmental conditions. The morphometric study was conducted on marks developed with magnetic powder in 7 different time intervals after deposition. 60 ridges were evaluated for each developed mark. Results suggest the possibility of using the morphometric method to determine an aging profile of latent palmprints on glass surface, aiming for forensic purposes.

Yuyang Zhou1, Tiande Guo [11] proposed a segmentation algorithm with this principle: the segmentation is to separate the neighbor regions that run out the dissimilarity tolerance, which should be set according to the intrinsical character of the images. The latent palmprint image segmentation function was developed with intensity gradient and frequency energy. Region growth was carried through a learning database of pure palmprint blocks for the dissimilarity tolerance threshold. Experiment results substantiate the robust feasibility of the textual automatic segmentation algorithm in differently complex cases.

Shanwen Zhang, Shulin Wang [12], proposed a novel method of palmprint feature extraction and identification using ridges transforms and rough sets. At first, the palmprints were converted into the time-frequency domain image by ridges transforms without any further preprocessing such as image enhancement and texture thinning, and then feature extraction vector was conducted. Different features were used to lead a detection table. Then rough set was applied to remove the redundancy of the detection table. The experimental results showed that the method provided higher recognition rate and faster processing speed.

3. RESEARCH METHODOLOGY

Ridge feature based palmprint matching is required in law enforcement applications because these recognition systems need to identify poor quality partial palmprints left at crime scenes as well as meet the requirements of courts of law. Ridge features comprise of Ridge Orientation and Ridge Frequency. The figure 1 given below illustrates the common ridge flow pattern.

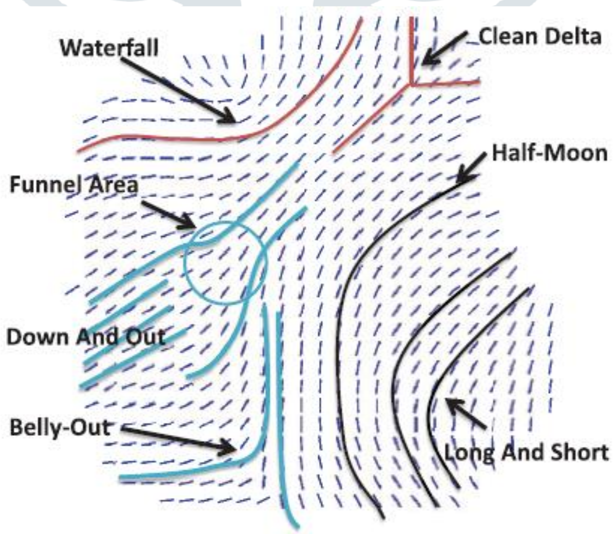

Figure 1: Common ridge flow patterns

FLOWCHART OF PROPOSED HYBRIDIZATION METHOD

The flow diagram of the proposed Hybridization method is shown in figure 2. The input palmprint image is preprocessed where the noise and the distortions are removed. The preprocessed image is normalized to extract the features namely ridge orientation and ridge frequency.

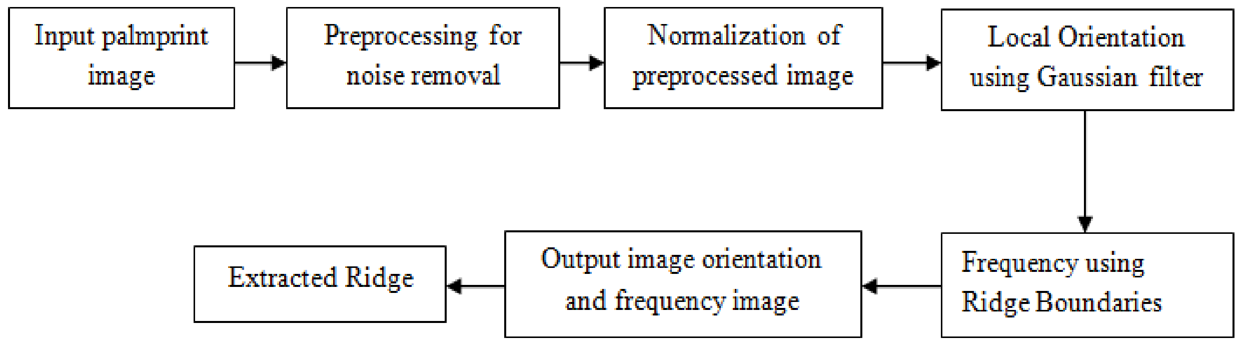

Figure 2: Steps in Ridge Extraction Algorithm

The input image is normalized to zero mean and the standard deviation is calculated. Gradient of the Gaussian filtered image is computed using vertical and horizontal Sobel operator. Least square for the local orientations are estimated. Local orientation is normalized using Gaussian filter to generate ridge orientation. Ridge frequency is estimated by computing the ridge space where the median number of pixels between the ridge boundaries is counted.

Algorithm 1: Ridge Extraction and matching

Input: Preprocessed Palmprint image I

Output: Ridge Orientation O and Frequency F

1. Normalize the preprocessed Input image I to zero mean and unit standard as I_{G_F}
2. Calculate Gradient of Gaussian filtered image I_{G_F} as G_I using Vertical and Horizontal Sobel operator.
3. Least square estimate of local orientation of ridges is calculated.
4. Local Orientation is normalized using Gaussian filter to generalize the ridge orientation O.
5. Frequency of ridges is estimated by computing the ridge space by counting the median number of pixels between ridges boundaries as F
6. Return O and F

res.

Algorithm 2: Normalization of Input Image

Input : preprocess image ,threshold
Output : Normalize image

Normalize-> Ridge_Normalization (preprocess image, threshold)
Find orientation from normalize
call orientation ->Ridge_orientation(Normalize)
Find frequency from normalize
call frequency ->Ridge_frequency (Normalize)
Sub function:
Normalize_1 -> Normalize the image to 0 to 1
Find the deviation
Deviation-> find standard deviation from Normalize_1
Calculate normalize
Normalize -> preprocess image - deviation image;

Orientation field characterizes the ridge orientation at each location in the palmprint. Orientation field shows high consistency among the same region of different palms and low consistency among different regions of the same palmprint. The orientation is performed on the normalized palmprint image.

Algorithm 3: Ridge Orientation Function

Input: Normalize image
Output : Orientation
Calculate Gaussian using Gaussian parameter
1st level calculation
Calculate gradient using image and Gaussian
Gx1 -> Image*gaussian_x
Gy1 -> Image*gaussian_y
Find x , y xy directions
Gxx=Gx1*Gx1
Gyy=Gy1*Gy1
Gxy=Gx1*Gy1
2nd level calculation
Gx2 -> image * Gxx
Gy2->image * Gyy
Gxx = Gx2*Gx2;
Gyy= Gy2*Gy2;
Gxy=Gx2*Gy2
Calculate square root of gradient
Denom-> sqrt(Gxy^2 + (Gxx - Gyy)^2)
Calculate sin and cos
Sinvalue->Gxy/denom
Cosvalue->(Gxx -Gyy)/denom
Find orientation
Orientation -> pi/2 + tan^-1 (Sinvalue + Cosvalue)/2

Ridge Frequency

The frequency is computed from the normalized palmprint image and the estimated orientation image. The ridge frequency is a popular feature extracted and it has been used for enhancing recognition algorithms. This feature describes the ridge distribution in a block.

Algorithm 4: Ridge Frequency Function

Input: Normalize image
Output: frequency
cosorient -> calculate mean -> cos(Normalize)
sinorient -> calculate mean->sin(Normalize)
Orient -> pi/2 + tan^-1 (cosorient + sinorient)/2
Find no of peaks:
No of peaks -> length (Orient)
Find Wavelength:
Wavelength -> (orient(end) - orient(start)) / No of peaks
Find frequency
frequency -> 1/Wavelength

Matching

Matching a pair of palmprint means to measure how different they are or to decide whether they belong to the same individual or not. The figure 3 illustrates the all the processing steps of ridge extraction and matching.

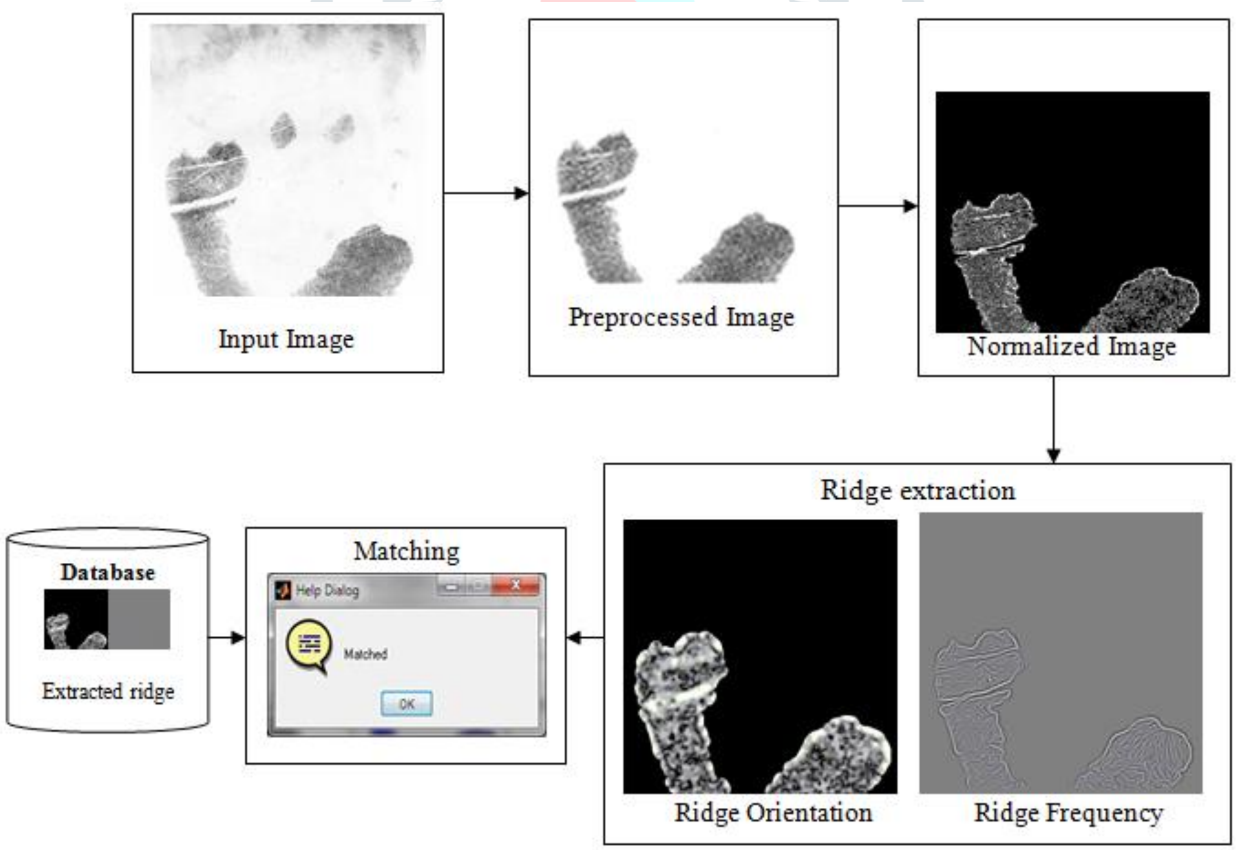

Figure 3: Matching palmprint with Ridge features

4. DATABASES USED

The experiments were carried out on the high resolution publicly available databases which are as follows:

- THU-HRPD database is larger in size and contains nearly 15,000 images. First subset contains 1,280 palmprint images from 80 subjects (two palms per person and eight impressions per palm) using a commercial palmprint scanner of Hisign.
- LPIDB v1.0 is a new resource available for the scientific community and it can be used to advance state-of-the-art latent palmprint identification. The database includes 380 latent palmprint images as well as the impressions and the minutiae positions/orientations manually and automatically labeled.

Table 1 given below describes the parameters used in database.

Table 1: Parameters used in Database

Parameters	THU-HRPD	LPIDB-v1.0
No. of Subjects	80	51
No. of images	1280	380
Resolution	500	500
Size	2040 x 2040	150 x 200 to 2000 x 8000
Depth	8 bits	8 bits

5. PERFORMANCE METRICS

The Parameters used to study the efficiency of the proposed algorithm are FAR, FRR, GAR and ROC which are described below:

False Acceptance Rate (FAR) - the probability of accepting an imposter i.e. a non-registered user is provided an access to a system.

$$FAR = \frac{Number\ of\ false\ acceptance}{Total\ number\ of\ attempts} \tag{3.1}$$

False Rejection Rate (FRR) - the probability of rejecting a genuine user i.e. a registered user is denied to gain access to a system.

$$FRR = \frac{Number\ of\ false\ rejection}{Total\ number\ of\ attempts} \tag{3.2}$$

Genuine Acceptance Rate (GAR) - the ratio of number of true matches found by the system to the total number of actual matches performed by the biometric system. This is defined as a percentage of genuine users accepted by the system.

$$GAR = \frac{Number\ of\ true\ matches}{Total\ number\ of\ matches} \tag{3.3}$$

Receiver Operating Characteristics (ROC) Curve - compares the performance of different systems under similar conditions or a single system under different conditions.

6. EXPERIMENTAL RESULTS

The experiments were carried out with the existing high-resolution palmprint databases to examine the performance of proposed methods which is compared with the existing method. The results obtained are plotted with the help of ROC curve to comparatively study the performance of various algorithms used.

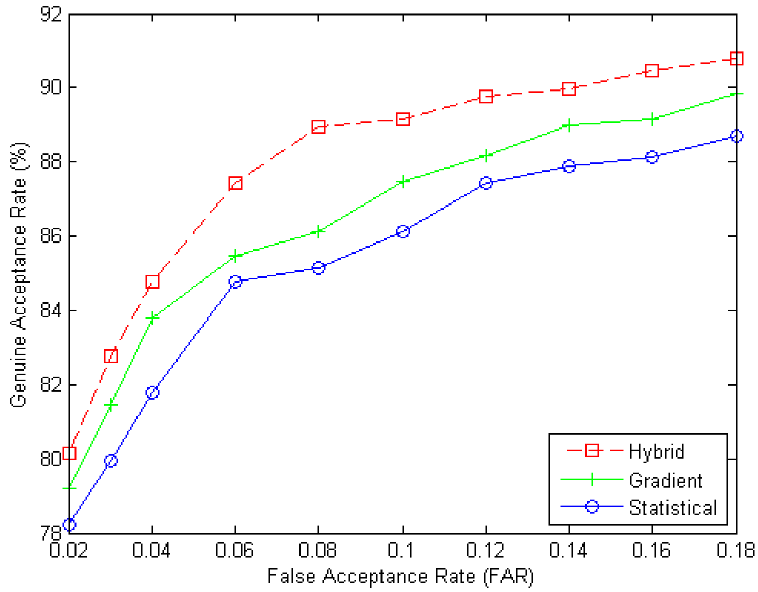

Figure 4: ROC curve for various methods using THU-HRPD

The above figure 4 shows the ROC curve using various methods such as Hybrid, Gradient and statistical method using THU-HRPD database. The Red, green, blue line shows the hybrid method, the Gradient method and the Statistical method.

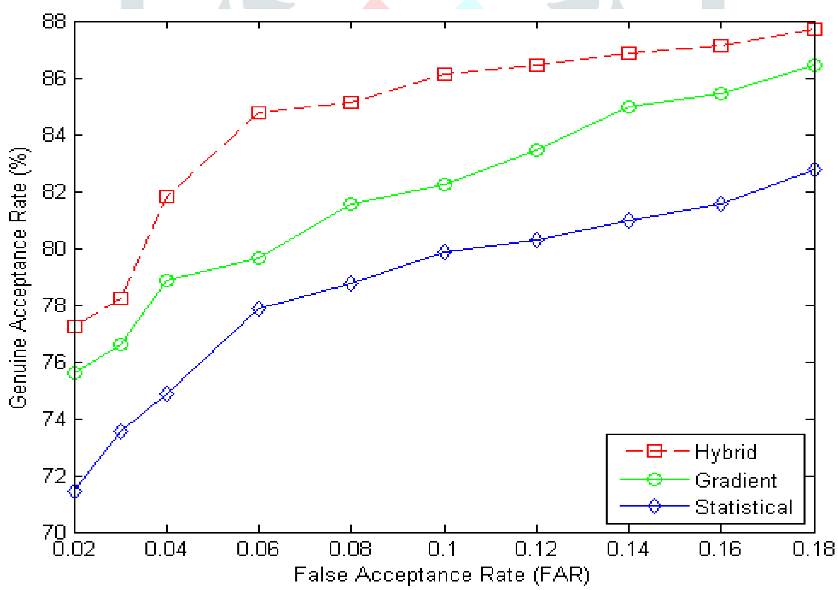

Figure 5: ROC curve for various methods using LPIDB v1.0

The above figure 5 shows the ROC curve using various methods such as Hybrid method, Gradient and statistical method using LPIDB v1.0 database. The Red, green, blue line shows the hybrid method, the Gradient method and the Statistical method.

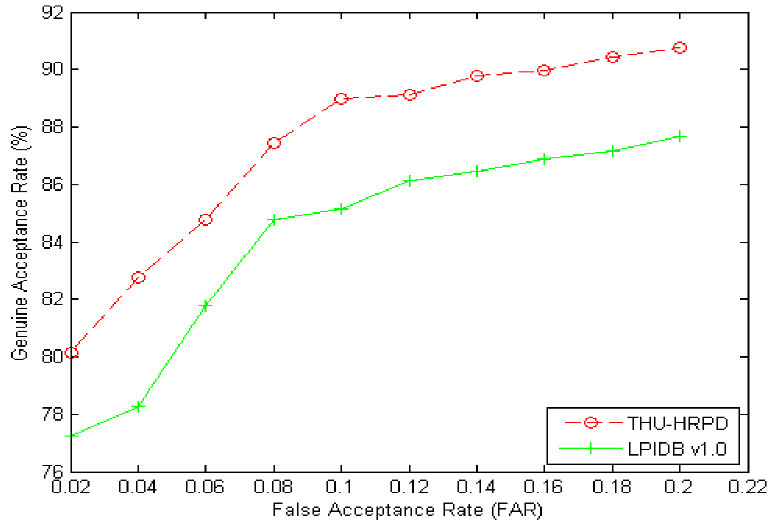

Figure 6: ROC curve for various Datasets

The above figure 6 shows the ROC curve which compares the performance of two different databases namely THU-HRPD and LPIDB v1.0 database. The red line stands for THU-HRPD database and the green line indicates the performance with LPIDB v1.0 database.

7. CONCLUSION

To deal with the effect of relative wide creases this paper designed an enhanced Gaussian filter to recover the broken ridges interrupted by both relatively wide and small creases, which significantly improved the efficiency of ridge extraction algorithm. Experiments were carried out with publicly high-resolution palmprint database. The results achieved have proved that the performance of the proposed algorithm is higher compared with existing algorithm.

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