Palmprint Enhancement Using Discrete Curvelet Transform

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Abstract

This paper presents a novel approach for enhancing palmprint image. Enhancement is a preprocessing step used to modify the contrast of the image and remove the noise. Traditional Histogram equalization techniques improve the contrast of the image but introduce spurious noise. Palmprint consists of fine features. In order to extract fine features from the palmprint image, enhancement has to be done. Fine features in the palmprint increases the accuracy of palmprint recognition. This paper provides enhancement based on curvelet which preserves the fine features without introducing noise. This method is applied for 100 test cases. Comparing with the histogram equalization techniques curvelet gives better result in the presence of noise. The experiment result shows high PSNR (Peak Signal-to-Noise Ratio) value for the Curvelet method.

Keywords: *Enhancement, palmprint, PSNR, Curvelet, Histogram.*

1. Introduction

In recent days, biometrics plays a vital role in personal identification system. Biometric features like fingerprint, face, iris, voice, ECG, Hand geometry, ear and palmprint are mostly used in identification system. Biometric features are unique and reliable. Moreover they provide high level of security since they cannot be lost, stolen, shared or forgotten. Furthermore fraud and repudiation are impossible. Palmprint has attracted the researchers due to its variety of features such as principal lines, wrinkles, crease, ridges, minutiae, and texture. The features are more since it has more area.

The palmprint authentication system consists of various steps. Fig. 1 illustrates the major steps in the palmprint identification system. Like other biometric systems palmprint authentication system has steps which include image acquisition, palmprint segmentation, palmprint enhancement, feature extraction and palmprint matching.

Ajay kumar et al.[1] deals with hand verification based on integration shape and texture. Here, image is processed with morphological operations to remove any isolated small blobs or holes. Jin Soo NOH et al. [2] deals with palmprint identification algorithm using hu invariant moments and otsu binarization. Here histogram equalization is used for enhancement. Slobodan Ribaric et al.[3] deals with biometric verification system based on the fusion of palmprint and face features. The first step in preprocessing is done which involves gaussian smoothing and contrast enhancement. Junta Doi et al. [4] deals with personal authentication based on discrete finger and palmar feature extraction. Noise reduction is done using a binary noise removal algorithm with repetitive morphological operations of erosions and dilations. A directional enhancing filter for the crease detection is applied, but the enhancement at the image acquisition stage is more effective. Ying-Han Pang et al.[5] deals with palmprint authentication with zernike moments invariants. Palmprint is enhanced with traditional technique. Jun-ying Gan et al [6] deals with palmprint recognition based on wavelet transform. Here enhancement is done using gray level mapping. [1]-[6] does not improve the contrast substantially. Furthermore they introduce noise in the palmprint image.

Yanxia Wang et al. [7] deals with an improved unsharp masking method for palmprint image enhancement. A fuzzy unsharp masking algorithm is presented to enhance the contrast of a palmprint image. This method introduces the fuzzy set theory into the unsharp masking scheme. Unsharp Masking (UM) approaches are simple and effective for contrast enhancement of high-frequency components. Most of the UM algorithms can effectively improve the contrast of principal lines, but insensitive to wrinkles. In order to further enhance the contrast of wrinkles, a half open membership function is used to transform the output of the filters into a fuzzy domain. The palmprint image is enhanced in fuzzy field. However, some speckle noises and breakpoints are observed in the enhanced images.

Jiwen Lu et el. [8] deals with palmprint recognition using wavelet decomposition and 2D principal component analysis. Here, after pamlprint acquisition, image denoising and histogram equalization is carried out. M. Arif et al. [9] deals with personal identification by hand recognition. Here, a morphological filter is employed to fill in all small gaps and blacken the isolated white pixels. Ajay kumar et al. [10] deals with personal recognition using hand shape and texture. Palmprint image is processed with morphological operations to remove any isolated small blobs or holes. Ying-Hang Pang et al. [11] deals with palmprint authentication with Zernike moment invariants. Here emphasis is on image enhancement which is a crucial and necessary part before feature extraction. Enhancement is done with a traditional algorithm. Jie Wu et al. [12] deals with hierarchical palmprint identification method using hand geometry and grayscale distribution features. Image is denoised with midvalue filter and histogram equalization. Maylor K.H.Leung et al. [13] deals with palmprint verification system. In the preprocessing step 3 x 3 averaging mask is used to remove noise and make line extraction more accurate. QI Zhenyu et al. [14] deals with automatic performance evaluation of palmprint recognition. Preprocessing is done to obtain a sub palmprint image for feature extraction and to eliminate the distortion caused by the rotation and translation. It consists of a series of image processing operations such as directional filtering, enhancement, binarization and thinning.

Fan Yang et al. [15] deals with information fusion of biometrics based-on fingerprint, hand-geometry and palm-print. The region of interested image is enhanced by means of local histogram equalization or gabor filter. Badrinath et al. [16] deals with efficient multi-algorithmic fusion system based on palmprint for personal identification. Here that palmprint image is enhanced, normalized and processed with morphological operations to remove any isolated small blobs or holes. Michal Choras [17] deals with emerging methods of biometrics human identification. Ear image preprocessing is with contrast enhancement, filtration and histogram equalization.

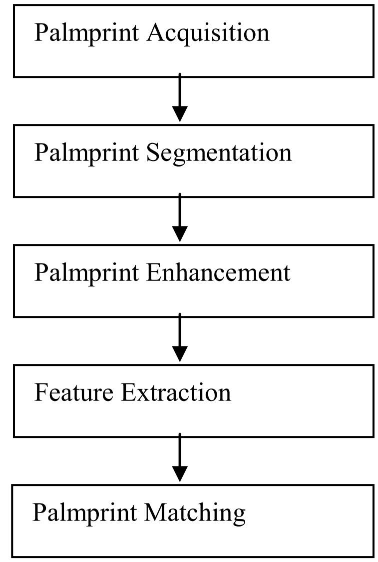

Fig.1 Palmprint Authentication System

Yan Zheng et al. [18] deals with offline palmprint image enhancement. Here, noise removal is done with orientation filters. Robert K Rowel et al.[19] deals with multispectral whole-hand biometric authentication system. Here, Morphological operators are then applied to remove the noise in the background and fill the holes in the hand region, producing a binary image of the hand. Wen-Shiung Chen et al. [20] deals with biometric verification by fusing hand g eometry and palmprint. A histogram equalization technique is used to enhance the R.O.I image of palmprint. [8]-[20] uses either histogram technique or morphological technique where considerable amount of noise is present. Yunyong Punsawad et al. [21] deals with palmprint image enhancement using phase congruency.

The proposed method aims to address the aforementioned limitations of the current methods by the application of curvelet transform. The paper is organized as follows. In section 2, the theoretical concepts of curvelet transform are described. In section 3, the application of curvelet transform to palmprint image and observations are discussed and the conclusion is discussed in section 4.

2. CURVELET TRANSFORM

1.1 Discrete Curvelet Transform

An important thing in curvelet transform is to restore sparsity by reducing redundancy across scales. In detail, one introduces interscale orthogonality by means of subband filtering. Different levels of the multiscale ridgelet pyramid are used to represent different subbands of a filter bank output. At the same time, this subband decomposition imposes a relationship between the width and length of the important frame elements so that they are anisotropic and obey width=length^2.The discrete curvelet transform of a continuum function $f(x_1,x_2)$ makes use of a dyadic sequence of scales, and a bank of filters $(P_0 f, \Delta_1 f, \Delta_2 f)$ with the property that the passband filter Δ_s is concentrated near the frequencies $[2^{2s}, 2^{2s+2}]$.

$$\Delta_s = \Psi_{2s} * f$$

$$\hat{\psi}_{2s}(\xi) = \hat{\psi}\ (2^{-2s}\xi) \tag{1}$$

In wavelet theory, one uses decomposition into dyadic subbands $[2^{2s}, 2^{2s+1}]$. . In contrast, the subbands used in the discrete curvelet transform of continuum functions have the nonstandard form $[2^{2s}, 2^{2s+2}]$. This is a nonstandard feature of the discrete curvelet transform well worth remembering.The curvelet decomposition is the sequence of the following steps.

Subband Decomposition: The object is decomposed into subbands

$$f \mapsto (P_0 f, \Delta_1 f, \Delta_2 f, ...) \tag{2}$$

Smooth Partitioning: Each subband is smoothly windowed into "squares" of an appropriate scale (of side length $\sim 2^{-s}$)

$$\Delta_s f \mapsto (w_Q \Delta_s f) \quad Q \in Q_s \tag{3}$$

Renormalization:Each resulting square is renormalized to unit scale

$$g_Q = (T_Q)^{-1}(w_Q \Delta_s f), Q \in Q_s \tag{4}$$

Ridgelet Analysis: Each square is analyzed via the discrete ridgelet transform.

In this definition, the two dyadic subbands $[2^{2s}, 2^{2s+2}]$ and $[2^{2s+1}, 2^{2s+2}]$ are merged before applying the ridgelet transform.

1.2 Digital Realization

In developing a transform for digital n by n data which is analogous to the discrete curvelet transform of a continuous function $f(x_1, x2)$, we replace each of the continuum concepts with the appropriate digital concept mentioned in the sections above. In general, the translation is rather obvious and direct. However, experience shows that a modification is essential. It is found that, rather than merging the two dyadic subbands $[2^{2s},2^{2s+2}]$ and $[2^{2s+1},2^{2s+2}]$ as in the theoretical work, in the digital application, leaving these subbands separate, applying spatial partitioning to each subband and applying the ridgelet transform on each subband separately leads to improved visual and numerical results. It is believed that the "à trous" subband filtering algorithm is especially well-adapted to the needs of the digital curvelet transform. The algorithm decomposes an n by n image as a superposition of the form

$$I(x,y) = c_J(x,y) + \sum_{j=1}^{J} w_j(x,y) \tag{5}$$

Where c_J is a coarse or smooth version of the original image I and w_j represents "the details of I " at scale 2^{-j} Thus, the algorithm outputs $J+1$ subband arrays of size n x n. [The indexing is such that, here, j = 1 corresponds to the finest scale (high frequencies).]

1.3 Algorithm for Digital Realization

Here a sketch of the discrete curvelet transform algorithm is presented.

1) Apply the à trous algorithm with J scales;

2) Set $B_1 = B_{min}$;

3) For j = 1,….J do

a) Partition the subband w_j with a block size B_j and

apply the digital ridgelet transform to each block;

b) If j modulo 2 =1 then $B_{j+1}=2 B_j$ then;

c) Else $B_{j+1}= B_j$.

The side length of the localizing windows is doubled at every other dyadic subband, hence maintaining the fundamental property of the curvelet transform which says that the elements of length about $2^{-j/2}$ serve for the analysis and synthesis of the jth subband $[2^j, 2^{j+1}]$.

3. RESULTS AND DISCUSSIONS

The input palms acquired using Nokia 2700 with resolution of 1200 × 1700 and those from IIT Delhi database are used . Palm print image database of IIT Delhi touchless palm print database (Version 1.0) [22] consist of the hand images collected from the students and staff at

IIT Delhi, New Delhi, India. This database has been acquired in the IIT Delhi campus during July 2006 - Jun 2007 using a simple and touch less imaging setup. All the images are collected in the indoor environment and circular fluorescent illumination is employed around the camera lens. Seven images from each subject, from each of the left and right hand, are acquired in varying hand pose variations. Each of the subjects is provided with live feedback to present his/her hand in the imaging region. The acquired images have been sequentially numbered for every user with an integer identification number. The resolution of these images is 800 × 600 pixels and all these images are available in bitmap format. The experiments are done with palmprint images of size 256 × 256 and 150 × 150.

The simulation is done in MATLAB Version 7.0.0.119920(R14).The program is run under Windows XP operation system with Lenovo 3000N100 Laptop ,Genuine Intel(R) CPU with T2050 @1.6 GHz ,500 MB RAM.

First the input image is enhanced without adding any noise. The proposed method is compared with the traditional techniques i.e., histogram Equalization(HE), Adaptive Histogram equalization(AHE) and Unsharp Masking .Then, Gaussian noise is added with the input image keeping sigma value equal to 8, and the image is enhanced.

3.1 PSNR

$$\text{MSE} = \left(\sum_i \sum_j | X(i,j) - Y(i,j) |^2\right)/\text{N} \qquad (6)$$

$$\text{PSNR} = 10\log_{10}\left((\text{L}-1)^2 / \text{MSE}\right) \qquad (7)$$

As N is the total number of pixels in the input or output image, MSE (Mean Squared Error) is calculated through (6). Based on MSE, PSNR is then defined as (7). Note that the greater the PSNR, the better the output image quality. PSNR is employed to quantitatively assess the degree of contrast enhancement.

PSNR values obtained for various methods with 256x 256 image are shown in table 1.

Table 1 PSNR Values

Methods	PSNR (db) Without Adding Noise	PSNR (db) With Addition of Gaussian Noise
HE	8.05526	6.3832
AHE	19.2682	6.3832
UM	27.4259	21.824
Curvelet	38.1047	35.4902

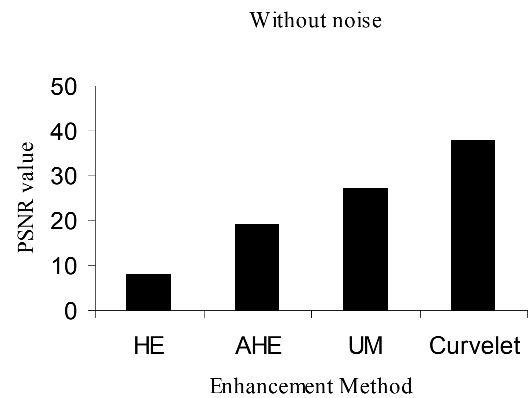

Fig. 2 PSNR Value Comparison withoutnoise

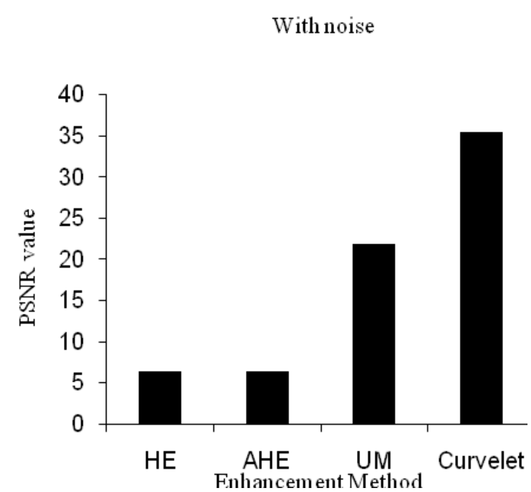

Fig. 3 PSNR Value Comparison withnoise

From Fig.2 and Fig.3 it is shown that the proposed method provides higher PSNR value both in the presence and absence of noise.

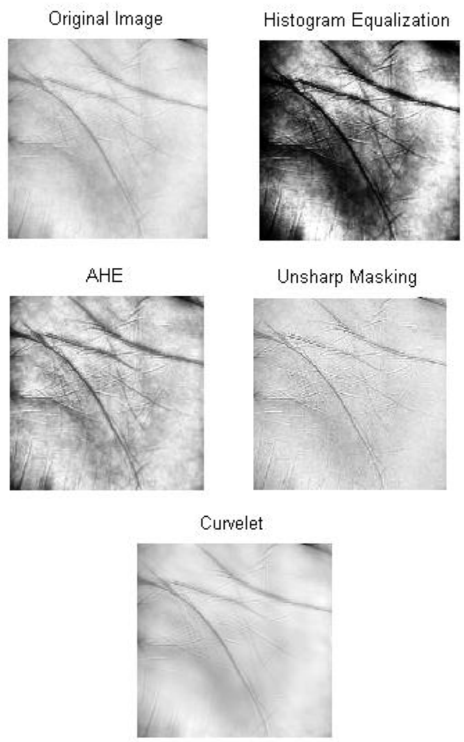

Fig. 4 Enhanced Images (without noise)

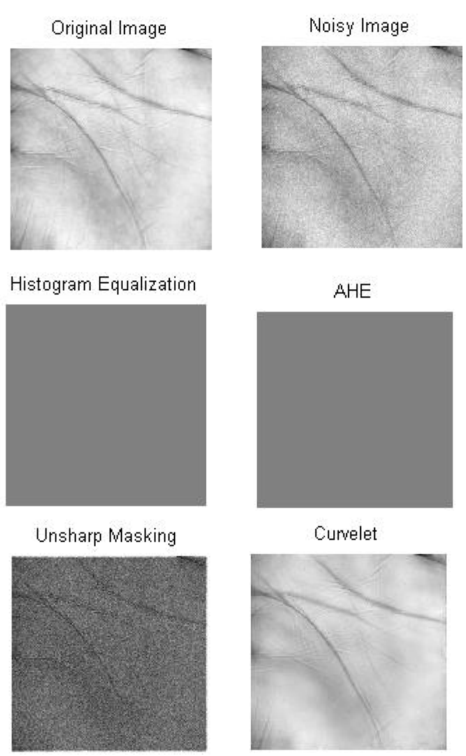

Fig. 5 Enhanced Images (with noise)

The result images are shown in Fig.4and Fig.5. From the observation, it is clear that curvelet provides high PSNR value. The visual appearance is fine in the case of curvelet. It is also observed that curvelet provides better enhancement with and without addition of noise, where as the traditional techniques histogram equalization, adaptive histogram equalization and unsharp masking do n ot provide enhancement in the presence of noise.

4. CONCLUSION

In this paper, curvelet transform based enhancement is proposed.Performance of traditional techniques and curvelet transform based denoising technique is compared. Performance of the technique is evaluated with 100 test cases .The observation shows that the proposed method gives better result. This eliminate noise in the input image and therefore more features can be extracted from the palmprint. Hence the accuracy will be more.

ACKNOWLEDGEMENT

The authors would like to thank Dr. Ajay Kumar of IIT, New Delhi for providing permission and help on downloading palmprint image database from IIT database.

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