Performance Analysis and Designing of Technique for Enhancement of Fingerprints based on the Estimated Local Ridge Orientation and Frequency

Virender Kadyan, Ritu Aggarwal

Abstract: ***Fingerprint identification is a growing and popular biometric identification technology. It includes two steps one is fingerprint verification and other is fingerprint recognition. Both of them use minutiae, such as end points and bifurcation points, as features. Therefore, how to appropriately extract minutiae from fingerprint images becomes an important step in fingerprint identification. Extracting features from fingerprints is an essential step in fingerprint verification and recognition. Many algorithms for this issue have been developed recently. on. The goal of this paper is to develop a system that can be used for fingerprint verification through extracting and matching minutiae. To achieve good minutiae, initially, extraction is done in fingerprints with varying quality, then preprocessing in form of image enhancement. Many methods have been joined to build a minutia extractor and a minutia matcher. A fast fingerprint enhancement algorithm, which can adaptively improve the clarity of ridge and valley structures of input fingerprint images based on the estimated local ridge orientation and frequency, is be implemented in this paper. Performance of the new developed system is then evaluated using visual analysis and goodness index value of enhanced image.***

Index Terms: ***Enhancement, Fingerprint, Ridges, Valleys.***

I. INTRODUCTION

Fingerprints are believed to be unique across individuals and across fingers of same individual. Even identical twins having similar DNA, are believed to have different fingerprints[1]. A fingerprint is the pattern of ridges and valleys on the surface of a fingertip [2]. Fingerprint recognition can be categorized into identification and verification. Fingerprint identification is the process of determining which registered individual provides a given fingerprint. Fingerprint verification, on the other hand, is the process of accepting and rejecting the identity claim of a person using his fingerprint. Fingerprint recognition can also be categorized into minutiae extraction based and spectral features of the image based. All technologies of fingerprint recognition, identification and verification, minutiae extraction based and spectral features based, each has its own advantages and disadvantages and it may requires different treatments and techniques. The choice of witch technologies to use is application specific. At the highest level, all fingerprint recognition systems contain two main modules feature extraction and feature matching. Feature extraction is the process that detects singular and all other minutiae points which are ridge ending and ridge bifurcation which differentiate one fingerprint from another, which impart individuality to each fingerprint." (as shown in Fig.1) from the original image that can later be used to represent each fingerprint. Feature matching involves the actual procedure to identify the unknown person by comparing extracted features from his/her fingerprint with the ones from a set of known persons.

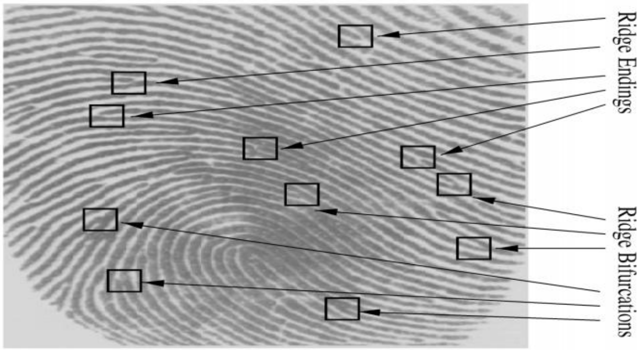

Fig1. Examples of ridge ending and bifurcation

II. GABOR FILTER

The Gabor function has been recognized as a very useful tool in computer vision and image processing, especially for texture analysis, due to its optimal localization properties in both spatial and frequency domain. There are lots of papers published on its applications since Gabor proposed the 1-D Gabor function. The family of 2-D Gabor filters was originally presented by Daugman as a framework for understanding the orientation-selective and spatial–frequency selective receptive field properties of neurons in the brains visual cortex [1], and then was further mathematically elaborated [2]. The 2-D Gabor function is a harmonic oscillator, composed of a sinusoidal plane wave of a particular frequency and orientation, within a Gaussian envelope. A complex 2-D Gabor filter over the image domain (x, y) is defined as

$$G(x,y) = \exp\left(-\frac{(x-x_0)^2}{2\sigma_x^2} - \frac{(y-y_0)^2}{2\sigma_y^2}\right) \times \exp\left(-2\pi i\left(u_0(x-x_0)+v_0(y-y_0)\right)\right) \quad (1)$$

where (x0, y0) specify the location in the image, (u0; v0) specifying modulation that has spatial–frequency w0= sqrt(u02 + v02) and orientation ϴ0 = arctan(v0/u0), and σx and σy are the standard deviations of the Gaussian envelope respectively along x-axis and y-axis. Derived from formula (1) by elaborately selecting

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above parameters, the even-symmetric real component of the original 2- D Gabor filer can be obtained, which is adopted in [1-3].

$$g(x,y;T,\phi)=\exp\left(-\frac{1}{2}\left[\frac{x_\phi^2}{\sigma_x^2}+\frac{y_\phi^2}{\sigma_y^2}\right]\right)\cos\left(\frac{2\pi x_\phi}{T}\right) \quad (2)$$

$$x_\phi = x\cos\phi + y\sin\phi \quad (3)$$

$$y_\phi = -x\sin\phi + y\cos\phi \quad (4)$$

where ϕ is the orientation of the derived Gabor filter, and T is the period of the sinusoidal plane wave. GABOR functions, in the form of Gabor filters (GFs) and Gabor wavelets[4], are applied for a multitude of purposes in many areas of image processing and pattern recognition. Basically, the intentions for using GF and log-GF [5] can be grouped into two categories; first, the GF aim at enhancing images, and the second common goal is to extract Gabor features obtained from responses of filter banks. Typical fields of application include:

a) Texture: Texture segmentation [5] and classification [6], with applications such as recognizing species of tropical wood or classifying developmental stages of fruit flies.

b) Medical and biological applications: In medical imaging, GFs are applied for the enhancement of structures such as finger veins and muscle fibers in ultrasound images [6], for the detection of blood vessels in retinal images, and for many other tasks such as analyzing event-related brain activity, assessing osteoporosis in radiographs, and modeling the behavior of simple cells in the mammalian visual cortex.

c) Optical character recognition: GFs are utilized for text segmentation, character recognition, font recognition, and license plate recognition [8].

d) Object recognition: Objects can be detected by GFs, e.g., cars. Moreover, GFs can be used for performing content-based image retrieval.

e) Biometrics: Gabor functions play an important role in biometric recognition. They are employed for many physical or behavioral traits including iris, face, facial expression, speaker, and speech, emotion recognition in speech, gait, handwriting, palmprint, and fingerprint recognition.

f) Fingerprint recognition: GF banks are used for the segmentation and quality estimation of fingerprint images, for core point estimation [5], classification, and for fingerprint matching based on Gabor features [6]. GFs are also employed for generating synthetic fingerprints. The use of the GF for fingerprint image enhancement was introduced [8].

III. METHODOLOGY

1. Reading of input finger print image.
2. Conversion in to gray scale image.
3. Assignment of some input parameter i.e. required mean and variance value for normalization of gray image.
4. Normalization of gray-scale image using above mentioned parameters so that it could have zero mean and one standard deviation.
5. Calculation of image gradients.
6. Estimate the local ridge orientation at each point by finding the principal axis of variation in the image gradients.
7. Initialization of some parameters i.e. window size, block size, minimum and maximum wavelength for estimation of ridge frequency.
8. Determine ridge frequency values across the image to estimate the fingerprint ridge frequency across normalized image by considering blocks of the image and determining a ridge count within each block.
9. Getting of median frequency.
10. Initialization of two input parameters i.e. bandwidth control and orientation control, so as to use them in designing of filter to enhance the ridge image.
11. Application of ridge filter with the help of above mentioned parameters and median frequency.
12. Binarization of new enhanced ridge image.
13. Display binary normalized image for where the values are one.

IV. EXPERIMENTAL RESULTS

The purpose of a fingerprint enhancement algorithm is to improve the clarity of ridges and valleys of input fingerprint images and make them more suitable for the minutiae extraction algorithm. The ultimate criterion for evaluating such an enhancement algorithm is the total amount of "quality" improvement when the algorithm is applied to the noisy input fingerprint images. Such an improvement can be assessed subjectively by a visual inspection of a number of typical enhancement results and from Goodness Index value. However, a precise and consistent characterization of the quality improvement is beyond the capability of subjective evaluation. Examples of the enhancement results are shown in Fig. below. From these figures, we can see that our enhancement algorithm does improve the clarity of the ridge and valley structures of input fingerprint images. All the simulation has been done using MATLAB R2012a as implementation platform using image processing toolbox and generalized MATLAB tool box. An image finger.jpg has been taken for implementation purpose shown in fig. 2 After that normalized image is calculated shown in fig 3. Frequency matrix image having block size of 36 is shown in fig 4 ,after that filtered and enhanced image is shown in fig.5 followed by binary normalized image shown in fig.6. The goodness index value of the enhanced image for the proposed method is 0.6714 as shown in Table I.

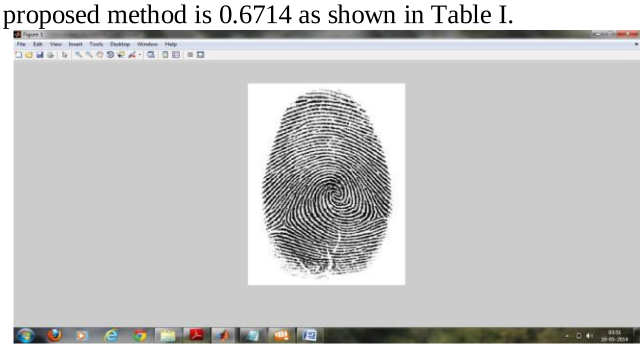

Fig 2 snap-shot of input finger print image

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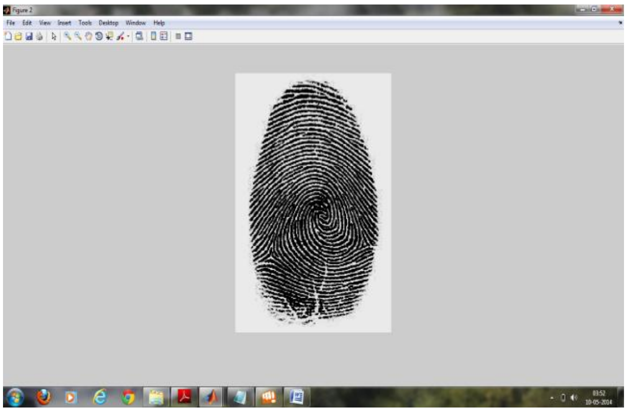

Fig 3 snap-shot of normalized image

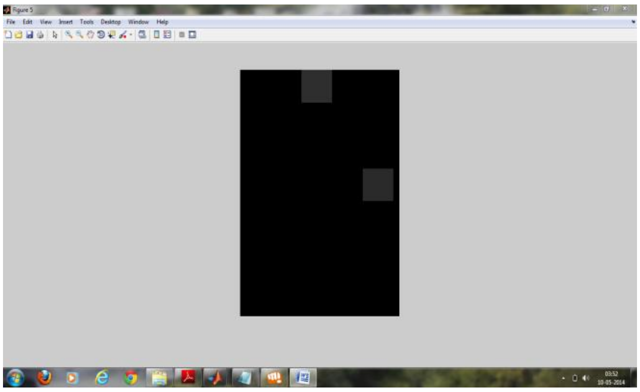

Fig 4: snap-shot of ridge frequency image

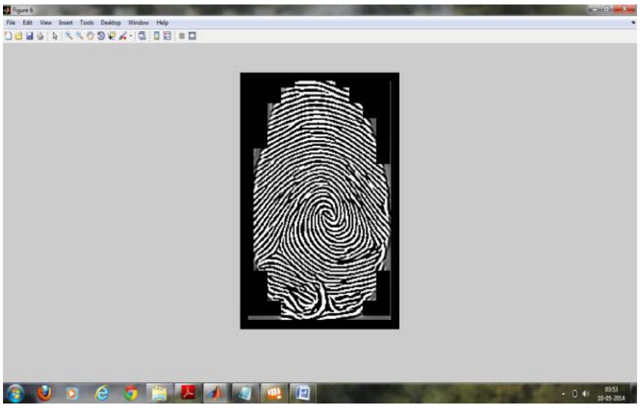

Fig 5: snap-shot of enhanced normalized ridge image

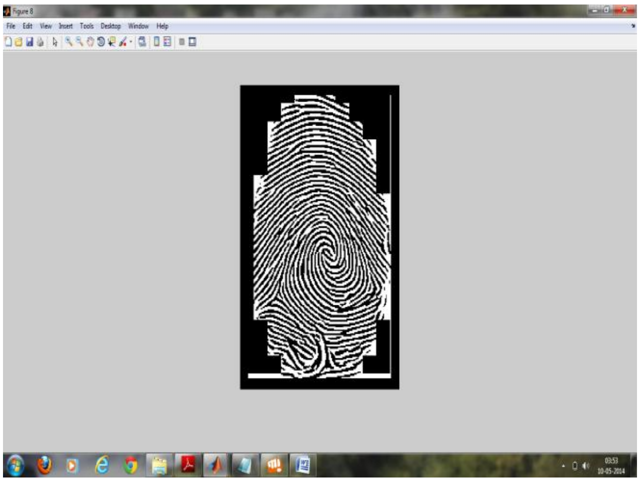

Fig 6: snap-shot of binary masked enhanced image

Table I. Comparison of Goodness Index of existing method with proposed method

Method	Goodness Index
Gabor Filter (Image 1)	0.55
Gabor Filter (Image 2)	0.52
Proposed method	0.6714

V. CONCLUSION

We have developed a fast fingerprint enhancement algorithm which can adaptively improve the clarity of ridge and valley structures based on the local ridge orientation and ridge frequency estimated from the input image. The performance of the algorithm was evaluated using the goodness index of the extracted minutiae and the performance of an online fingerprint verification system which incorporates our fingerprint enhancement algorithm in its minutiae extraction module. Experimental results show that our enhancement algorithm is capable of improving both the goodness index and the verification performance. The algorithm also identifies the unrecoverable corrupted regions in the fingerprint and removes them from further processing. This work has described a method for RF estimation using curved regions and image enhancement by filters. For low-quality fingerprint images, in comparison with existing enhancement methods, improvements of the performance have been shown. The experimental results show that the proposed scheme is able to handle various input contexts and achieves the best performance in combination with existing verification algorithms. It is noted that the operation has been performed on MATLAB platform in our simulation. The future works related to this paper are as follows. Pixel processing could be used instead of block processing to reduce the computation complexity, and try to improve the speed of the proposed method. Moreover, the proposed method with fixed feature is very suited for a secure biometric system coupling it with bio-hashing, which can be used in cancelable biometrics by canceling and reissuing biometric templates and for protecting privacy in biometrics systems. Other improvement is that the potential of the matching performance rests upon a better OF estimation. As long as OF estimation errors occur, it is necessary to choose the size of the GFs and the standard deviations of the Gaussian envelope with care in order to balance strong image smoothing while avoiding spurious features. An exploration of a locally adaptive choice of these parameters, depending on the local image quality and, for example, the local reliability of the OF estimation. In addition, it will be of interest to apply the curved-region-based RF estimation and curved GFs to latent fingerprints.

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