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Enhancement of biometric image by implementing Gabor filter

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Abstract
Biometric based systems are commonly used for verification and identification of an individual. The most common biometric trait used because of high disparateness and high performance are fingerprints, iris and face. Fingerprint may get degraded or corrupted because of diversity in skin, noise and impression conditions. Thus, to concur this situation and obtain an effective minutiae location estimation, image enhancement techniques are required. In this paper, the experiment has been done on the fingerprint image enhancement using the Gabor filter. The local frequency and orientation information can be obtained by tuning the Gabor filter to a specific frequency and direction, so that the extracted texture information could improve the quality of image. The algorithm has been developed using Open CV & has been tested on the live fingerprint Images obtained by using DACTYScan84c scanner.

Keywords: biometrics; fingerprint; gabor filter; open CV; DACTYScan84c

1. Introduction

Excellent perception of the fingerprint is an important step in fingerprint verification process. The detection of fingerprint texture is the most important element in fingerprint recognition process. The modern technology failing due to imperfection in live-scan fingerprint-sensors. Now to resolve this problem we need fingerprint enhancement process which can be done by designing a Gabor Filter. Gabor filter detects all the native orientation and frequency information from a fingerprint image. Gabor fiber is calibrated to such a specific frequency and direction that it can collect all the native frequencies and orientation information. In this way, they are best to extract the basic texture information from the image. In signal processing we the signal filter to filter out all the signal noise which is the most important element in signal processing. This filter enhances the image quality by making its ridges differentiable from each other. Similarly, in fingerprint recognition we use Gabor filter provides us great selectivity to filter out all the unwanted elements of the fingerprint image. Gabor filter helps to characterize the information of fingerprint such as directional angles, the width of hills and valleys and other information based on parameters used.

2. Background

The biometry [2] refers to the identification of an individual by utilizing the certain physiological or behavioural traits that are associated with the concerned person. The main perspective is that the personal identification is to be associated with the particular individual with an identity. It plays an important role in our society like in security, financial services, health care, electronic, telecommunication, government, etc. As we know that passwords and ID cards have been used to modest access to restricted systems. However, security can be easily infringed in these systems.

Fingerprint identification is one of the most important biometric [3, 4]. Each individual has unique fingerprints. A pattern of ridges and valleys on the surface of the finger forms a fingerprint. Fingerprints are fully formed at about seven months of foetus development and its ridge formations do not change throughout the life of the person. Due to less equal-error-rate, fingerprint recognition is very accurate. Even the identical twins having similar DNA have different fingerprints. This property makes fingerprints a very excellent and secure biometric identifier. The uniqueness of a fingerprint is exclusively determined by the local ridge characteristics and their relationships [3, 5]. A total of 150 different local ridge features namely islands, short ridges, enclosure, etc. have been identified [5]. The two most important local ridge characteristics, called minutiae, are

- Ridge ending.
- Ridge bifurcation.

There is a point where the ridge ends abruptly, known as the ridge ending and where a ridge diverges into branch ridges that point is known as ridge bifurcation. A good quality fingerprint typically contains about 40–100 minutiae. Examples of minutiae are shown in Fig. 1.

Fig 1: Minutiae present in Fingerprint image

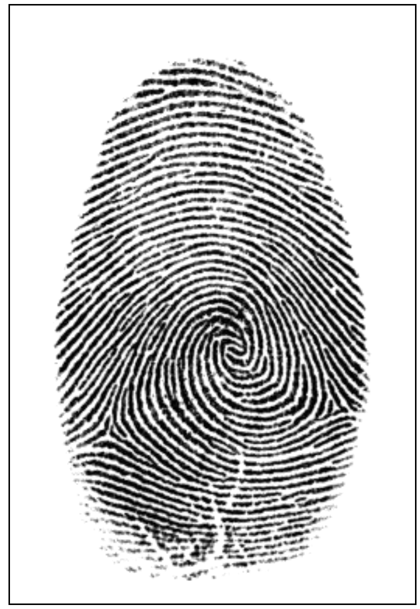

Fig 2: Good quality fingerprint image

Automatic fingerprint matching depends on the comparison of local ridge characteristics and their relationships to make the personal identification [3]. To take the automatic and reliable extract minutiae from the input fingerprint images is an important step in the fingerprint matching. The performance of a minutiae extraction algorithm depends on the quality of the input fingerprint images. In an ideal fingerprint image, valleys and ridges alternate and flows in a locally constant direction. In these conditions, the minutiae can be precisely located and ridges can be easily detected. Figure 2 shows an example of good quality live-scan fingerprint image.

But due to variations in the impression conditions, ridge configuration, acquisition devices, skin conditions, etc., a significant number of acquired fingerprint images are of poor quality. The ridge structures in the poor-quality are not always well-defined and, hence, they cannot be correctly detected. This leads to following problems:

1. a large amount of genuine minutiae may be ignored,
2. a significant number of spurious minutiae may be created,
3. Introduction of large errors in their localisation i.e. position and orientation

Examples of fingerprint images of very poor quality, in which ridge structures are completely corrupted, are shown in Fig. 3.

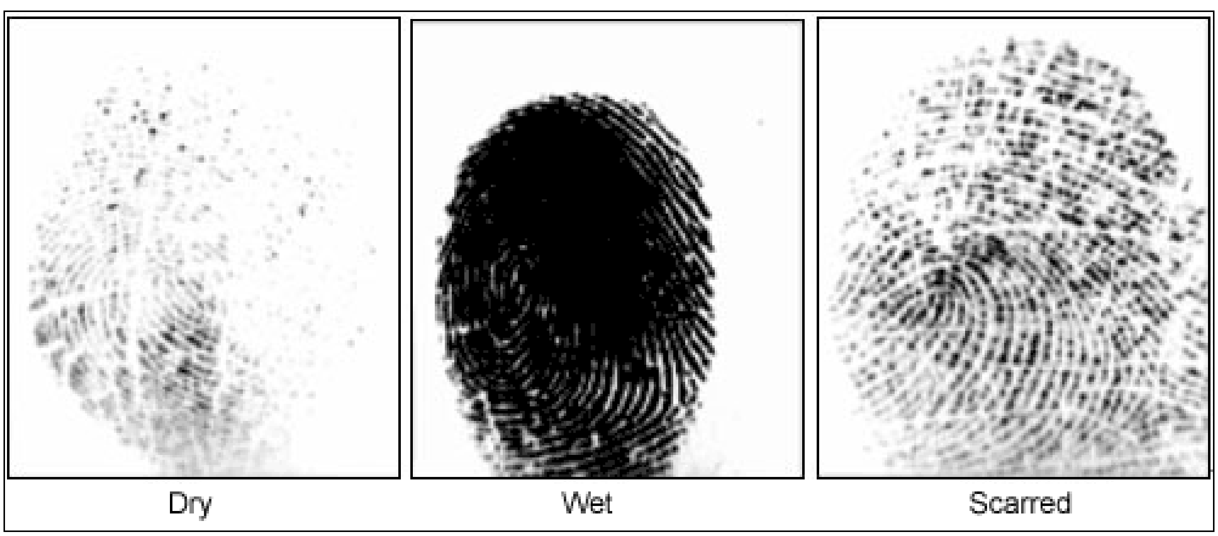

Fig 3: Poor quality fingerprint image

In order to ensure the performance of the minutiae extraction algorithm will be robust with respect to the quality of the input fingerprint images. To improve the clarity of the ridge structures an enhancement algorithm is necessary. Figure 4 shows the flow diagram of fingerprint matching procedure.

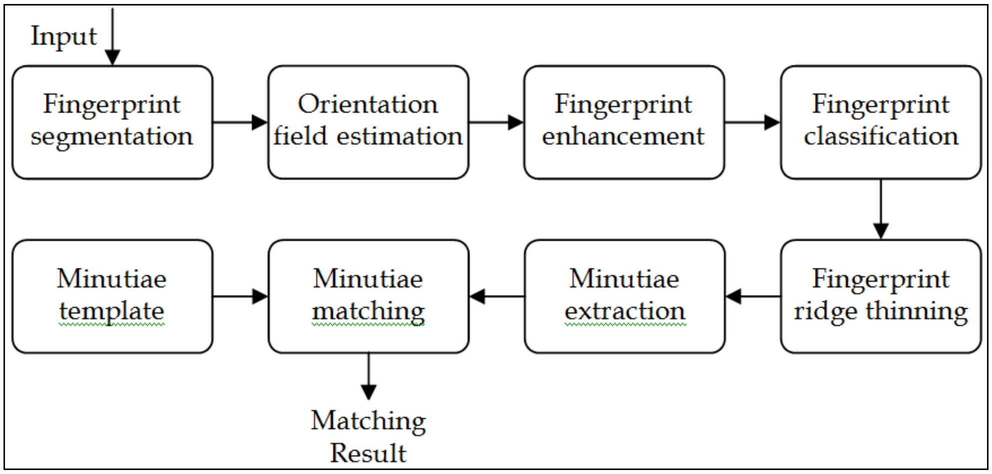

Fig 4: Fingerprint matching procedure

Fingerprint enhancement can be conducted on either
1. Binary images.
2. Gray-level images.

A binary image consists of the ridge pixels having value one for ridge pixel and non-ridge pixels have a value of zero. By applying a ridge extraction algorithm on a gray-level fingerprint image the binary image can be obtained [6]. However, information about the true ridge structures is often lost after applying a ridge extraction algorithm on the original gray-level images, depending on the performance of the ridge extraction algorithm. Therefore, enhancement of binary ridge images has its existing limitations.

In a gray-level fingerprint image, valleys and ridges form a sinusoidal-shaped plane wave having a well-defined frequency and orientation. A number of techniques [7, 8, 9, 10] have been proposed to enhance gray-level fingerprint images.

3. Gabor Filter

A 2-D Gabor filter consists of a sinusoidal plane wave of the particular orientation and frequency, modulated by a Gaussian envelope [11]. Gabor filters are employed as they are frequency-selective and orientation-selective properties. The filter can be tuned to give maximal response to ridges at a specific orientation and frequency in the fingerprint image using these properties. To preserve the ridge structures while reducing noise, tuned Gabor filter can be used. An even symmetric Gabor filter in the spatial domain is defined as [12]:

$$G(x, y; \theta, f) = e^{\{-\frac{1}{2}\left[\frac{x_\theta^2}{\sigma_\theta^2}+\frac{y_\theta^2}{\sigma_\theta^2}\right]\}} * (\cos 2\pi f\, x_\theta)$$

$x_\theta = x\cos\theta + y\sin\theta$

$y_\theta = -x\sin\theta + y\cos\theta$

Where, θ is the orientation of the Gabor filter, σ_x & σ_y are the standard deviations of the Gaussian envelope along the *x*-and *y*-axes, respectively, f is the frequency of the cosine wave, x_θ & y_θ define the *x* and *y* axes of the filter coordinate frame, respectively.

For fingerprint enhancement, we have implemented an algorithm [13] which consists of four main stages:

- normalisation,
- Gabor filtering,
- ridge frequency estimation, and
- Orientation estimation.

In addition to these four stages, we have implemented three additional stages that include:

- Thinning,
- binarization, and
- segmentation

3.1 Segmentation

It is the process of separating the foreground regions in the image from the background regions. The foreground regions correspond to the clear fingerprint area containing the ridges and valleys & background corresponds to the regions outside the borders of the fingerprint area. When the minutiae extraction algorithms are applied to the background regions of an image, it results in extraction of noisy and false minutiae. Thus, segmentation is employed. The background regions generally exhibit a very low gray-scale variance value, whereas the foreground regions have a very high variance in a fingerprint image. Hence, to perform the segmentation a method based on variance thresholding [14] can be used. The gray-level variance for a block of size W*W is defined as:

$$V(k) = \frac{1}{w^2}\sum_{i=0}^{w-1}\sum_{j=0}^{w-1}\left(I(i,j) - M(k)\right)^2$$

where *V* (*k*) is the variance for block *k*, *I*(*i*, *j*) is the gray-level value at pixel (*i*, *j*), and *M* (*k*) is the mean gray-level value for the block *k*.

3.2 Normalisation

The next step in the enhancement process of fingerprint is image normalisation. It is used to standardise the intensity values in an image by adjusting the range of gray-level values so that it lies within a desired range of values. Let *N*(*i*, *j*) represent the normalised gray-level value at pixel (*i*, *j*), and *I* (*i*, *j*) represent the gray-level value at pixel (*i*, *j*). Then the normalised image is defined as:

$$N(i,j) = \left\{ M0 + \sqrt{\frac{V0\left(I(i,j)\right) - M^2}{V}} \right\} if\left(I(i,j)\right) > M$$

$$N(i,j) = \left\{ M0 - \sqrt{\frac{V0\left(I(i,j)\right) - M^2}{V}} \right\} otherwise$$

Where *M* and *V* are the estimated mean and variance of *I* (*i, j*), respectively, and *V*0 and *M*0 are the desired variance and mean values respectively. Normalisation does not change the ridge structures in a fingerprint. It is performed to standardise the dynamic levels of variation in gray-level values, which facilitates the processing of subsequent image enhancement stages.

3.3 Orientation Estimation

The native orientation of the ridges in fingerprint defines the orientation field of a fingerprint image. As the consecutive Gabor filter stages rely on the native orientation so the orientation estimation step is an essential step in fingerprint enhancement process. One of the many estimation methods which was implemented by Lin Hong least mean square estimation method which is widely used to compute the orientation of fingerprint image. To get the finer and accurate orientation estimation we go through pixel-wise scheme instead of using block-wise orientation scheme.

3.4. Ridge Frequency Estimation

Another parameter used in the construction of Gabor fibre is native ridge frequency. The initial step in the ridge frequency estimation stage is to divide the image into a matrix of blocks of size A*A. With the help of frequency image, we can represent the native frequency of ridges in a fingerprint. In the Followed step, the grey-scale values of each pixel in every block located in the orthogonal direction of the native ridge orientation are projected in the form of a sinusoidal-shaped wave with native minimum points based on the ridges in the fingerprint.

3.5 Binarization

Based on ridges minutiae extraction depends on two factors which are represented by black pixels and the valleys represented by white pixels as stated above Binarization is a process of converting a grey-level image into a binary image. Gabor filter generated wave has zero DC component, which means that the resulting image has overall pixel value of zero. This binary image consists of two level of information the foreground having ridges and the background having valleys.

3.6 Thinning

This operation reduces the foreground pixel at the extent until they are one pixel wide. Thinning algorithm is applied to a fingerprint image to conserve the connection between ridge structures while assembling a skeletonized version of the binary image. This is the terminal step in image enhancement performed to minutiae extraction prior.

4. Implementation and Result

To implement Gabor Filter for fingerprint image enhancement, a C++ code is written in Microsoft Visual Studio using library files of OpenCV version 2.4.9. A rotation algorithm is also implemented to rotate unrotated images. The performance of the enhancement algorithm was also assessed on NIST spacial fingerprint database (500 images; 10 per individual) and real time database (scanner: DACTYscan84c, Take 10 samples of each image). The following images show the result obtained:

(a) (b)

(c) (d)

Where,

1. shows Input image
2. Shows Rotated image
3. Shows Cropped image
4. Shows Enhanced image using Gabor filter.

5. Conclusion

In the presented work, the experiments have been done on fingerprint images. The algorithm has capability to improve the quality of ridge and valley structures based on the native ridge orientation and ridge frequency which could adaptively enhanced the biometric images. The performance of the algorithm was evaluated using the goodness index of the extracted minutiae. This is a major riche of algorithm because such unrecoverable regions do appear in some of the corrupted fingerprint images and they are extremely harmful to minutiae extraction. Also algorithm has capability to aligned the query image if the given image is out of phase, due to of this property result could be improved. These features suggested that enhancement algorithm should be integrated into an online fingerprint verification system. This algorithm we can implement on other biometric images like face, iris and improve the quality of image. In future this algorithm could be implemented in hardware language on FPGA.

References

1. Vutipong Areekul, Ukrit Watchareeruetai, Kittiwat Suppasriwasuseth, Saward Tantaratana. "Seperable Gabor Filter Realization for Fast Fingerprint Enhancement, 2005.
2. Leung M. Engeler, Frank. "*Fingerprint image processing using neural network*". Proceedings of the IEEE conf. on Computer and communication systems. 1990, 671-774.
3. Lee HC, Gaensslen RE. *Advances in Fingerprint Technology*. New York, NY: Elsevier, 1991.
4. Newham E. *The Biometric Report*. New York, NY: SJB Services, 1995.
5. Moenssens A. *Fingerprint Techniques*. London: Chilton Book Company, 1971.
6. Jain A, Hong L, Bolle R. "On-Line Fingerprint Verification," IEEE Trans. Pattern Analysis and Machine Intelligence. 1997; 19(4):302-314.
7. Danielsson PE, Ye QZ. "Rotation-Invariant Operators Applied to Enhancement of Fingerprints," Proc. Ninth ICPR. 1988, 329-333.
8. O'Gorman L, Nickerson JV. "An Approach to Fingerprint Filter Design," Pattern Recognition. 1989; 22(1):29-38.
9. Ratha N, Chen S, Jain AK. Adaptive Flow Orientation Based Feature Extraction in Fingerprint Images, *Pattern Recognition*. 1995; 28(11):1,657-1,672.
10. Sherstinsky A, Picard RW. "Restoration and Enhancement of Fingerprint Images Using M-Lattice: A Novel Non-Linear Dynamical System," Proc. 12th ICPR-B. 1994, 195-200.
11. Daugman JG. "*Uncertainty relation for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters*". Journal of the Optical Society of America (A). 1985; 2(7):1160-1169.
12. Jain AK, Farrokhnia F. Unsupervised texture segmentation using Gabor filters. Pattern Recognition 24. 1991; (12):167-186.
13. Dankmeijer J, Waltman JM, Wilde AGD. Biological foundations for forensic identification based on fingerprints. Acta Morphologica Neerlando-scandivanica. 1980; 18(1):67-83.
14. Mehtre BM. Fingerprint image analysis for automatic identification. Machine Vision and Applications. 1993; *6*(2):124-139.