

EFFICIENT REGION OF INTEREST EXTRACTION METHOD WITH TWO STAGE ENHANCEMENT SCHEME FOR LOW QUALITY FINGERPRINT IMAGES

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Abstract

Fingerprints are the oldest and most generally used variety of identity verification. The performance of any fingerprint recognizer extremely depends on the fingerprint image quality. Because of advanced input contexts, quality input fingerprint pictures forever exist with cracks and scars, poor ridges and valley contrast ridges. Because of this reasons fingerprint recognition system needs economic improvement strategies. In this paper we have a tendency to propose two stage improvement schemes in spatial and frequency domain and is followed by economical Gabor filter ROI segmentation scheme. Experimental results show that our planned methodology provides higher segmentation accuracy compared to existing strategies.

Introduction

Wide usage of biometric data for person biometric identification functions, act of terrorism prevention measures and authentication process simplification in computer systems has raised vital attention to irresponsibility and potency of biometric systems. Biometric science utilizes the measurements of a person's behavioral characteristics (keyboard strokes, mouse movement) or biological characteristics (fingerprint, iris, nose, eyes, jaw, voice pattern, etc.). Fingerprint is one among the foremost promising strategies among biometric techniques and has been used for individual authentication since nineteenth century. The two elementary premises on that fingerprint recognition relies are: fingerprint details are permanent and fingerprints of people are unique. A fingerprint is made of a group of curves. Historically, in law enforcement applications the acquisitions of fingerprint images was performed by exploitation ink-technique. Currently days they're captured as live-scan digital images non heritable by directly sensing the fingerprint surface with an electronic fingerprint scanner. The fingerprint pattern displays different features at different levels. At level 1, the foremost evident structural characteristic of fingerprint can be a pattern of the lines (ridges) flowing in varied patterns. This level is additionally referred to as international level of fingerprint analysis. At this level fingerprint pattern exhibits one or a lot of regions wherever ridge lines are characterized by high curvature and frequent termination. These regions or singular regions are normally used for distribution a finger-

print to a group of five distinctive categories (arch, tented arch, left loop, right loop, double loop and whorl) with the aim of simplifying search and retrieval. At native level or level two fingerprint images are characterized by discontinuity of ridges. The two most prominent ridge characteristic, referred to as minutiae are ridge termination and ridge bifurcation.

A typical fingerprint-based recognition system works in two distinct modes: enrollment and recognition. the aim of the enrollment mode is to create a database. throughout this mode, an enrollee fingerprint is captured and processed in three stages: Fingerprint Reading, Image Preprocessing, and have Extraction. once the feature extraction stage, a group of representative features of the enrollee fingerprint is saved within the in the. throughout the recognition mode, a fingerprint to be recognized undergoes a similar three process steps as within the enrollment mode. The result is compared with a feature set template from the database in the feature matching stage. A match score that measures the similarity between the query feature set and database feature set is calculated. Higher values indicate higher confidence during a match.

Need of Fingerprint Image Enhancement

Fingerprint enhancement is often conducted on either binary ridge images or gray-scale images. Binarization before enhancement can generate additional spurious minutiae structures and lose some valuable original fingerprint information; it conjointly possesses additional difficulties for later enhancement procedure, thus it is inherent limitations of this method. Completely different techniques for gray-level fingerprint images enhancement are projected assuming that the native ridge frequency and orientation are often reliably estimated. Picture element oriented enhancement schemes like histogram equalization, Mean and Variance normalization Wiener filtering [1] improve the legibility of the fingerprint however don't alter the ridge structure. L.O.Gorman et al. proposed the use of enhancement filters for fingerprint image enhancement. Hong and Jain have shown that ridges and valleys in a gray fingerprint image, forms a sinusoidal-shaped plane wave that possesses a clearly-defined frequency and orientation and used Gabor filter. Shen et al. applied Gabor filter to image sub-blocks and concluded that a good quality block are often identified by the outputs of Gabor filter bank. Green-berg proposed the use of an anisotropic filter that is based on structure adaptive filter-

ing. Sherlock and Monro and Kamei and Mizoguchi perform contextual filtering fully within the Fourier Domain. the most reason for performing enhancement is to eradicate the noise within the fingerprint images, illuminate the parallel ridges and valleys and protect actuality configuration of them. [2] The efficiency of fingerprint image enhancement algorithm is greatly depends on the quality of the fingerprint images. so as to get robust performance of a fingerprint image enhancement algorithm, which will improve the transparency of the ridge structures, is extremely essential.

Fingerprint Enhancement Methods

R.C. Gonzalez and R.E. Woods [3] have explained in his book that there's no general theory of image enhancement. once an image is processed for visual interpretation, the viewer is that the final choose of how well a particular methods works. Most of the standard checks are used as a criterion, that determines image rejection, or a performance measurement of image enhancement algorithm. There have existed a spread of research activities on the stream of reducing noises and increasing the contrast between ridges and valleys within the gray-scale fingerprint pictures. Preferred among of them are spatial domain and other is frequency domain enhancement technique.

- **Spatial domain** refers to the image plane itself, and image processing methods in this category are based on direct manipulation of pixels in an image. Spatial domain process discussed above can be denoted by the expression:

$$g(x, y) = T[f(x, y)]$$

Where, $f(x, y)$ is an input image, $g(x, y)$ is an output image and T is an operator defined over the neighborhood of (x, y) .

- **Frequency domain** consists of modifying the Fourier transform of an image and then computing the inverse transform [Discrete Fourier Transform (DFT)] to get back to input image. Thus given a digital image $f(x, y)$, of size $M \times N$, the basic filtering equation in which we are interested has the form:

$$g(x, y) = \tau^{-1}[H(u, v) F(u, v)]$$

Where, τ^{-1} is the IDFT, $F(u, v)$ is the DFT of the input image $f(x, y)$, $H(u, v)$ is the filter function and $g(x, y)$ is the filtered output image. Specification of $H(u, v)$ is simplified considerably by using functions that are symmetric about the center. This is accomplished by multiplying the input image by -1^{x+y} prior to computing its transform [3].

Need of Fingerprint Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to

change and alter the illustration of an image into one thing that's a lot of significant and easier to analyze. On the basis of collection procedure, fingerprint images will usually be classified into three classes, namely, rolled, plain and latent [4]. Rolled fingerprints are obtained from rolling the finger from one facet to the opposite so as to capture all ridge details of the fingerprint. Plain fingerprints images are acquired by pressing the fingertip onto a flat surface. Since rolled and plain prints are obtained in an attended mode, in order that they are sometimes of excellent visual quality and contain adequate info for reliable matching. However, latent fingerprints are sometimes collected from crime scenes, during which the print is lifted from object surfaces that were unwittingly touched or handled. The matching between latent and rolled/plain fingerprints plays an important role in identifying suspects by enforcement agencies.

Fingerprint Segmentation Methods

A number of fingerprint segmentation strategies are known from literature, which can be roughly divided into block-wise methods and pixel-wise methods. Block-wise strategies first partition a fingerprint image into non overlapping blocks of a similar size, and so classify the blocks into foreground and background based on the extracted block-wise features. Pixel-wise methods classify pixels through the analysis of pixel-wise features. The commonly used features in fingerprint segmentation include gray-level features, orientation features, frequency domain features, then forth. during this work efficient Gabor filter based segmentation scheme is proposed.

The contribution of this paper is that our scheme is based on learning from images; so it is able to handle the complicated input contexts. The proposed of this projected technique are as follows.

- 1) Employing a two-stage enhancement scheme for the low-quality fingerprint image in each the spatial domain and also the frequency Domain based on the learning from the images.
- 2) The first-stage enhancement scheme enhances the contrast Of ridges and valleys and repairs the ridge structures fine within the low-quality images and also the second-stage filter can get the filters parameters from each the original image and also the first-stage enhanced image rather than exploit from the original image only, thus serving to within the next stage of enhancement.
- 3) Within the first-stage processing, native normalization is employed to scale back the variations in gray-level values on ridges and furrows rather than using traditional global normalization.

4) employing a local compensation filter to enhance the fingerprint Image with a mask enhances the ridges pixels gray level values on the local ridge orientation, whereas reducing the gray-level values of non-ridges pixels.

5) within the second stage enhancement Exponential band pass filter is employed for enhancing in frequency domain. The used filter is separable in both angular and radial domain.

6) in the ending economical Gabor filter based segmentation algorithm used for extracting ROI from second stage enhanced image.

Related Work on Fingerprint Enhancement and Segmentation

Human experts habitually use the context info of fingerprint images, like ridge continuity and regularity to help in identifying them. this means that the underlying morphogenetic method that created the ridges doesn't give irregular breaks in the ridges except at ridge endings.

Because of continuity and regularity properties of the fingerprint image, corrupted region is recovered using contextual info of the neighboring area.

Spatial Domain Filtering

The spatial-domain techniques involve spatial convolution of the image with filter masks that is simple for operation. For computational reasons, such masks should be tiny within the spatial extent.

In [1], S. greenberg et al. propose two ways for fingerprint image enhancement. the primary one is carried out using local histogram equalization, Wiener filtering, and image binarization. The second methodology uses a novel anisotropic filter for direct gray scale enhancement. The results achieved are compared with those obtained through another ways. each ways show some improvement within the minutiae detection method in terms of either efficiency or time needed.

In [5], Zhang et al. proposed an enhancement algorithm employing a space-frequency federated filtering scheme is proposed, that adapts the filtering methods to the input images according to a pre defined quality factor. the quality issue is calculated on the orientation field filtered image. solely components of the images of that quality issue don't meet the need are filtered by the Gabor filter. Experiments show that the planned algorithm is computationally efficient, with constant level of the enhancement performance.

The most popular approach to fingerprint enhancement that was proposed in [6] is based on a directional Gabor filtering kernel. The algorithm uses a properly oriented Gabor kernel

that has frequency-selective and orientation-selective Properties, to perform the enhancement. These properties enable the filter to be tuned to provide maximal response to ridges at a specific orientation and frequency within the fingerprint image. However, not like Fourier bases or discrete cosine bases, using Gabor elementary functions has the subsequent problems: Gabor elementary functions do not form a tight frame; they are bi orthogonal bases; and there's no rigorously justifiable reason for selecting the Gabor kernel over different directionally selective filters, like directional derivatives of Gaussian or steerable wedge filters [7].

More recent works that are based on reaction-diffusion techniques can be found in [8] and [9].

Frequency Domain Filtering

Unlike spatial-domain techniques, filters within the frequency domain are used to calculate convolutions effectively from the whole image instead of from a small area of the filtered point within the spatial domain. This section deals with other filters that are defined explicitly within the frequency domain.

In [10], Nandini et al. introduces hybrid sort fingerprint image enhancement wherever within the discrete Fourier transform (DFT) based mostly} adaptive regularized constraint total least square De-convolution is performed followed by discrete wavelet transform (DWT) based maximum a posterior estimator. proposed method is tested on standard lab FVC2002 and experiment result on this dataset show that proposed technique of enhancement and restoration has provided higher improved representation of fingerprint for extraction of minutiae points that operates iteratively and switches between two different domains DFT and DWT. the overall system has shown an increased rate of recognition accuracy of the system especially when the fingerprints are degraded.

In [11], the authors proposed enhancing the fingerprint image using the STFT analysis. It acquires the block frequency through the STFT analysis and estimates the local ridge orientation too. A directional band pass filter is utilized to enhance the fingerprint image in blocks. However, owing to the advanced input contexts of the low-quality image, not all of the irretrievable regions of the fingerprint will be recovered clearly, because it is tough to accurately estimate some parameters of the filters through a simple STFT analysis. Thus, the algorithm must be improved to enhance the irretrievable regions of low-quality images.

Other frequency-domain enhancement algorithm can be found in [12].

Fingerprint Segmentation Methods

Different methods to fingerprint image segmentation are identified from literature, like adaptive Total Variation Model [13], Directional Total Variation Model [14], technique based on combination of ridge orientation and frequency features [15], technique based on orientation field information combined with statistical characteristics of gray [16], Ridge template Correlation [17], technique using three component features, being the coherence, the mean and therefore the variance [18].

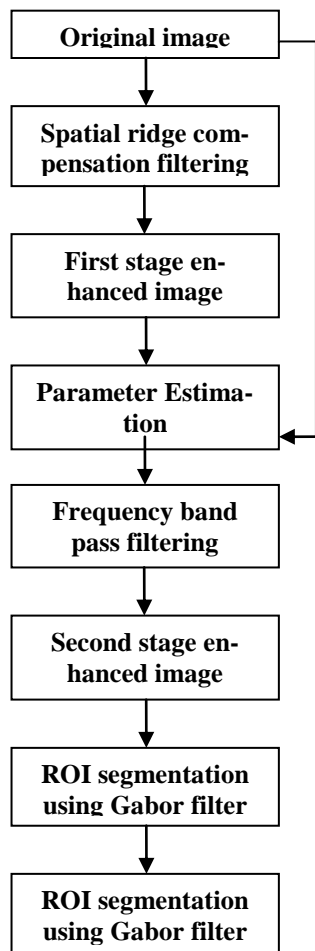


Fig1. Diagram of all process of Proposed ROI interest segmentation method

Proposed Region of Interest Segmentation Method with Two Stage Enhancement Scheme

According to the analysis of existing algorithms they are not satisfactory in enhancing and segmenting low quality fingerprint images. To overcome the demerits of those methods we have a tendency to propose an economical segmentation methodology with two stage enhancement scheme. Fig1 depicts the design of the overall method.

First Stage Enhancement: Spatial Ridge Compensation Filter

The first stage performs ridge compensation on the ridges in the spatial field. This step enhances the fingerprint's local ridges using the neighbor pixels during a small window with a weighted mask on the orientation of the local ridges. every pixel within the fingerprint is replaced with its weighted neighbor sampling pixels in a little window and with the controlled contrast parameters along the orientation of the local ridges. Meanwhile, the filter enhances the gray-level values of ridges' pixels on local ridge orientation, while reducing the non-ridge pixels' gray-level values; so, it is able to connect the broken bars and remove the smears in the fingerprint image. Unlike this article has been accepted for inclusion during a future issue of this journal. Content is final as presented, with the exception of pagination.

1) *Local Normalization*: This step is employed to scale back the native variations and standardize the intensity distributions so as to systematically estimate the native orientation [19]. The constituent wise operation doesn't modification the clarity of the ridge and furrow structures however reduces the variations in gray-level values on ridges and furrows, that facilitates the next process steps.

2) *Local Orientation Estimation*: This step determines the dominant direction of the ridges in several parts of the fingerprint image. this can be a essential process, and errors occurring at this stage are propagated to the frequency filter. we used the gradient technique for orientation estimation and an orientation smoothing technique using Gaussian window [6].

Second Stage Enhancement: Frequency Bandpass Filter

In the second-stage process, polar coordinates (ρ, ϕ) are used to show the filters as a separable function; the filters used are separable in the radial and angular domains. Using an exponential band pass filter as the radial filter, this has a desired steep attenuation in the bandwidth. Using local frequency and local orientation as the parameter estimation based on the learning from the images for fingerprint filter design.

1) *Local Orientation Estimation by Learning*: The dominant direction of the ridges in different parts of the fingerprint image by learning from the images. The orientation is estimated as similar in the first-stage filtering, in which the gradient method is used for orientation estimation. However, the new value for orientation $\theta(x, y)$ is calculated in the enhanced image after the first stage enhancement.

2) *Local Frequency Estimation by Learning*: Estimate the inter ridge separation in several regions of the fingerprint image. The local frequency is calculated by applying FFT to the blocks by $F = \text{FFT}(\text{block image})$ [11] and therefore the local frequency is pixel processing. The formula for the computation of the new frequency is similar to using the frequencies both from the enhanced image and the original image, the new frequency equals the average value of its neighbor if their difference is larger than a threshold value, as an alternative it equals the frequency that is acquired from the enhanced image. A frequency error-correcting method is applied when the calculated frequency to be outside of the range is assumed to be invalid [6]. The obtained frequency is also used to design the radial filter.

3) *Coherence Image*: The coherence indicates the connection between the orientation of the central block and those of its neighbors within the orientation plot. The coherence is related to the dispersion measure of circular data, and it is outlined as

$$C(x, y) = \frac{\sum |\cos(\theta(x, y) - \theta(x_i - y_i))|}{W \times W}$$

4) *Frequency and Bandpass Filtering*: The whole smoothing filtered image is divided into overlapping sub images, and for every sub image, the subsequent operations are performed

a) *FFT domain*: The FFT of each sub image is obtained by removing the dc component, $F = \text{FFT}(\text{block_ftimg})$.

b) *Angular filter*: The angular filter F_a is applied, which is centered on the local orientation image and with the bandwidth inversely proportional to the coherence image using (6).

c) *Radial filter*: The radial filter F_r is applied, which is centered on the local frequency image using (20).

d) *Filtered image*: The block is filtered in the frequency domain, i.e., $F = F \times F_a \times F_r$.

e) *Reconstructed image*: The enhanced image is reconstructed by final image = IFFT (F).

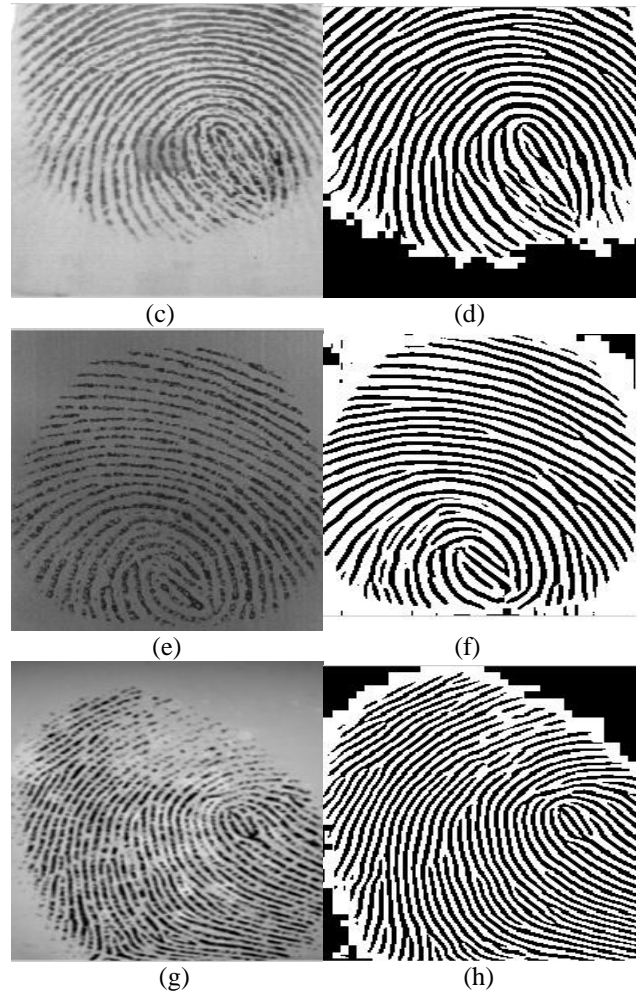


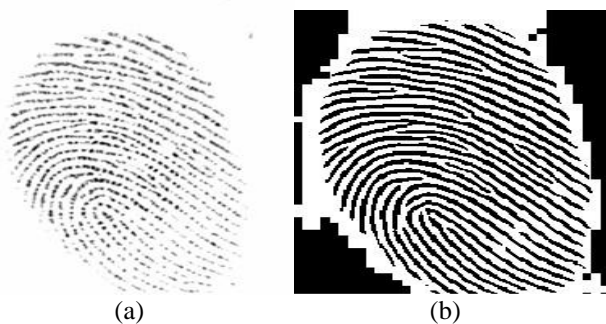
Fig 2. Results of the proposed region of segmentation algorithm that is applied to fingerprints from four FVC2004 databases DB1–DB4. (a), (c), (e), (g) Original images. (b), (d), (f), (h) our ROI extracted images.

Region of Interest Segmentation Using Gabor Filter Bank.

Gabor filter based segmentation scheme is applied on two stage enhanced image to obtain region of interest image so that fingerprint recognition process become much easier task. Gabor filter based segmentation is done as follows.

A 2-D Gabor filter bank is created. By using this filter bank Gabor features of the image is extracted. Gabor features includes both frequency selective and orientation selective properties. Then by using these features segmentation is carried out on the enhanced image. The feature vectors are normalized to zero mean and unit variance.

Experimental results shows that it provide better segmentation accuracy.



Experimental Results

Some results of the proposed Region of Interest Segmentation scheme with two stage enhancement using FVC databases is shown in fig 2. We observed that some incorrect ridge structures are enhanced in the low quality images with our proposed algorithm and also efficiently extracts the region of interest from noisy background.

Our proposed algorithm is implemented in MATLAB and segmentation accuracy is calculated using the following formula

$$\frac{TP+FP}{TP+FP+TN+FN} \times 100$$

(TP: True Positive, FP: False Positive, TN: True Negative, FN: False Negative).

In Fig 3. Shows the difference in accuracy between proposed method with existing one.

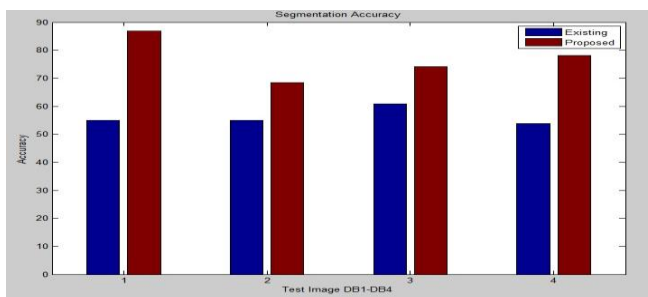


Fig3. Segmentation accuracy graph of proposed system with existing system over FVC 2004 database.

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