Fingerprint Recognition System for Personal Identification

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Abstract

Fingerprints are widely used in biometric techniques for automatic personal identification work. In this paper, a fingerprint recognition system is developed to identify a person according to fingerprint image on Myanmar National Registration Cards (NRCs). Generally, fingerprint identification approaches are minutiae-based and texture-based. Although the minutiae-based method is popular and extensively used method for fingerprint identification, it shows poor performance for low quality images. In proposed system, the texture-based approach for fingerprint recognition using Discrete Wavelet Transform (DWT) is developed. To reduce the search time and computational complexity, the proposed system classifies the fingerprint types according to ridges direction by singular candidate analysis using an extended relational graph. And then, the system finds the local features of the fingerprint using DWT and it is compared to the subset of the database containing that type of fingerprints using Euclidean distance metric. The performance of the proposed system can be evaluated by measuring its False Reject Rate (FRR) and False Accept Rate (FAR). The effectiveness of the proposed system can be confirmed through the experimental results.

Keyword: fingerprint recognition, extended relational graph, Discrete Wavelet Transform

1. Introduction

Biometrics is formed from the person's selected unique physical attributes which may be applied for the purpose of automated personal identification [1]. Commonly use biometrics for personal identification system contains face, fingerprints, hand geometry, handwriting, iris, vein, gait and voice. Fingerprint is the most interesting and oldest human identity used for recognition of individual and widely used in biometric techniques for automatic personal identification. Fingerprints of any individual are unique (even in the case of identical twins), remain the same over lifetime, and are easy to collect. A pattern of ridges, valleys and minutiae can be extracted. Although Fingerprints were initially introduced for criminals' investigation, and their verification, nowadays fingerprints are also involved in an increasing number of applications, such as physical access control, employee identification, and national ID card identification system. Fingerprint can be grabbed using inked impression on a paper or sensors.

Ridges and valleys generally run parallel to each other, and their patterns can be analyzed on a global and local level. Global level analysis of the fingerprint image is done to extract singular regions like core point in figure 1. According to the global level features, fingerprints can be classified into five different types: left loop, right loop, whorl, arch and tented arch as shown in figure 2. Analyzing a fingerprint on the local level provides the necessary information to accurately distinguish one fingerprint from another.

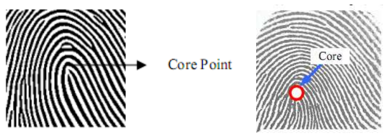


Figure 1. Core points

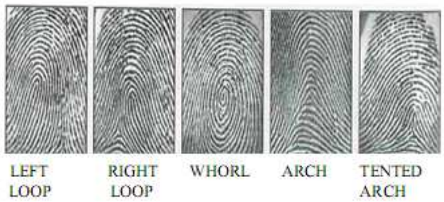


Figure 2. Fingerprint classes

Several methods of automatic fingerprint identification have been proposed in the literature. In minutiae-based approaches, a minutia detected in a fingerprint image can be characterized by a list of attributes that includes the minutia position, the minutia direction, and the type of minutia (ending or bifurcation).[2][3] The representation of a fingerprint pattern thus comprises the attributes of all detected minutiae in a so-called minutiae set. Some minutiae types are termination or ending, bifurcation, lake, dot or island, spur, crossover etc. The minutiae sets may suffer from false, missed, and displaced minutiae, caused by poor fingerprint image quality and imperfections in the minutiae extraction stage [7].

Another class of finger-print matching algorithms doesn't use the minutiae features of the fingerprint. These methods usually match features extracted from the image by means of certain filtering or transform operations; hence they are named image-based methods [4]. In [4], the 2D wavelet decomposition on J octaves of the image is used as the feature for recognition. These approaches require less preprocessing or post processing effort than minutiae-based methods. While minutiae-based methods normally require a minutiae location process [5] [6], image-based methods match two fingerprint images directly, based on their texture features.

In this paper, we propose an image-based approach towards fingerprint recognition. The fingerprint images are matched based on features extracted in the wavelet transform domain. Firstly, as a global analysis, the fingerprint is classified to one of pre-specified types to reduce search time and computational complexity by singular candidate analysis using an extended relational graph. Secondly, at local level, we apply DWT to extract local features and matching is done using Euclidean distance metric. The proposed method is more efficient than conventional minutiae based methods for real time authentication systems with large size databases.

The rest of the paper is organized as follows: section 2 describes the overview of the proposed system is. Section3 presents the enhancing steps. Fingerprint classification is described in Section 4. Finally, in Section 5, the concluding remarks are given.

2.Related Work

There has been a lot of work in various types of fingerprint identification. Based on our survey related to fingerprint classification, it has been observed that most of the existing works are aimed to classify the fingerprint database based on the minutiae sets, singular points and other techniques. Most systems detect minutiae points as fingerprint features and these points are used for matching. Minutiae extraction is very difficult if the quality of image is poor. Jianjiang Feng [13] proposed descriptor-based minutiae matching algorithm emphasis on minutiae descriptors and the computation of matching scores. The work presented in S.LinLin [7] used wavelet domain features to recognize fingerprints. The 64-subband structure of the FBI fingerprint compression standard is used to directly extract the wavelet features of the fingerprint image without preprocessing. A.Pokhriyal [14] used pseudo Zernike moments (PZMs) and wavelet transforms to extract the global and local features of fingerprint. PZMs are robust to noisy images, invariant to rotation and have a good image reconstruction capability. PZMs have been used for global analysis and so they are used to extract global features. Wavelets are good at local analysis and so they help to extract local features.

3. Overview of the Proposed System

The overview of the proposed fingerprint identification system is shown in figure 3. Firstly, image enhancing step is performed. Then, the orientation flows are detected and core point is extracted. The DWT is applied for extracting the fingerprint features. After classifying the fingerprint types, feature matching is performed to a subset of database according to the fingerprint type.

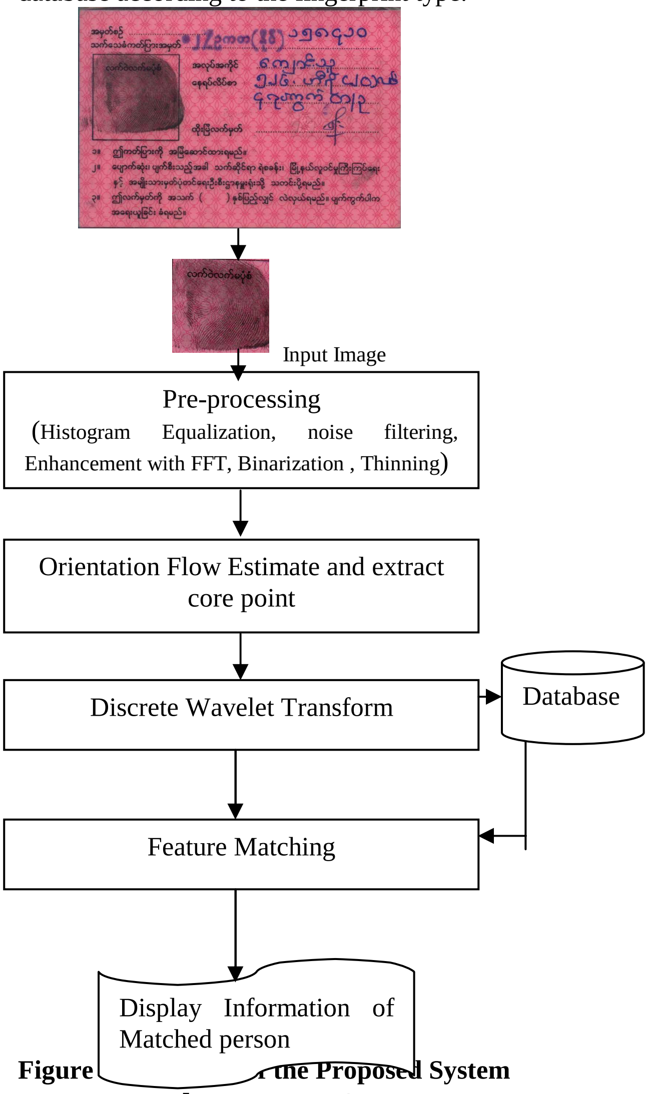


Figure [illegible] the Proposed System

4. Image Enhancement Steps

Because there is noise in original fingerprint images, and fingerprint images may be in bad quality, we cannot identify the singular point area efficiently. In order to reduce the influence of noise, we preprocess the input fingerprint images. The main steps involved in the image enhancing include: (a) enhancement (b) binarization (c) segmentation, and (d) thinning.

Image Binarization: In this step, an 8-bit grey level fingerprint image is transformed into a 1-bit image with 1-value for ridges and 0-value for furrows.

Image Segmentation: The objective of the fingerprint segmentation is to extract the region of interest (ROI) which contains the desired fingerprint impression. In this work, the gradient based fingerprint segmentation approach [11] was used and the segmentation results were found satisfactory even for the low quality images.

Image Thinning: This step aims to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. Here, an iterative, parallel thinning algorithm was used for thinning the binarized fingerprint image [12].

Fingerprint enhancement results are shown in figure 4.

Fast Fourier Transform (FFT): The input fingerprint image is pre-processed on both the spatial and frequency domain. In the spatial domain, histogram equalization technique was applied for better distribution of the pixel values over the image to enhance the perceptional information. In the frequency domain, the image was divided into small processing blocks (32×32 pixels) and the Fast Fourier transform (FFT) was applied in the following way –

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\cdot \exp\left\{-j2\pi\cdot\left(\frac{ux}{M}+\frac{vy}{N}\right)\right\} \quad (1)$$

Where u = 0, 1, 2,...., 31 and v = 0, 1, 2,..., 31.

In order to enhance a specific block by its dominant frequencies, the FFT of the block as multiplied by its magnitude for a number of times. Here, the magnitude of the original FFT = abs(F(*u*,*v*)) = |F(*u*,*v*)|.

$$g(x,y) = F^{-1}\left\{F(u,v)\cdot |F(u,v)|^{k}\right\} \quad (2)$$

where F^{-1} (F(*u*, *v*)) is done by:

$$f(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v)\cdot \exp\left\{j2\pi\cdot\left(\frac{ux}{M}+\frac{vy}{N}\right)\right\} \quad (3)$$

for x = 0, 1, 2, ..., 31 and y = 0, 1, 2, ..., 31. The value of k in equation (2) is an experimentally determined constant, however based on our experimentation a better result was found for k =0.5. So with an appropriate selection of k value, the ridges and the overall appearance of the image can be improved, which is useful for proper feature extraction and classification.

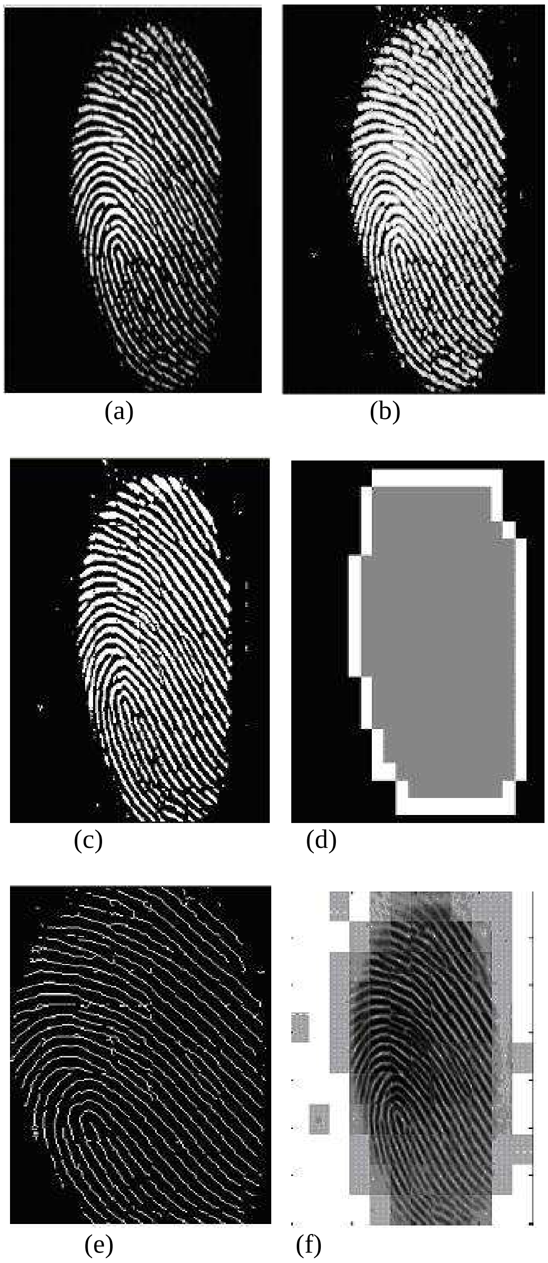
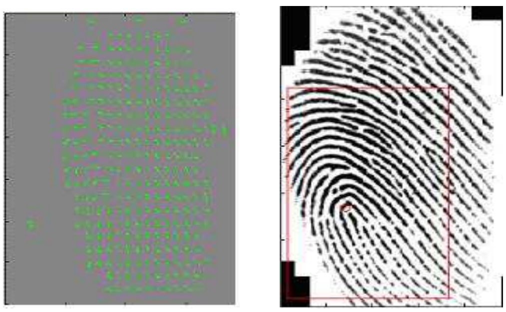


Figure 4. Fingerprint enhancing results (a) Original Image (b) Histogram equalization (c) Binarization (d) Region of Interest(ROI) (e) Thinned Image (f) Enhancement by FFT

5. Fingerprint Types Classification

To reduce the search time and computational complexity, classification is necessary. This allows matching of fingerprints to only a subset of those in the database. Large volumes of fingerprints are being collected in everyday applications-for e.g. The FBI database has 70 million of them. An input fingerprint is first matched at a coarse level to one of the pre-specified types and then, at a finer level, it is compared to the subset of the database containing that type of fingerprints only. In this work, the directional image is generated from the input fingerprint image to find the core point. In our system, we use the algorithm presented in [13] and the extended relational graph is generated from the directional image. Each node in the extended relational graph is corresponding to each segment in the directional image. Each edge in the extended relational graph shows the adjacent relationship between segments. When two segments are placed adjacently, the edge is bridged between corresponding nodes. Then the core point is extracted by the extended relational graph analysis. The depth first search against the extended graph is adopted to find the core point. According to the core point and ridge direction, we can classify the fingerprint types and continue to identify the local features and matching is performed with features in database. In figure 5, the orientation image and detected core point is shown.

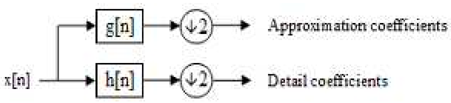
Wavelet transform (WT) represents image as a sum of wavelets on different resolution levels. The power of the WT is that it offers high temporal localization for high frequencies while attempts good frequency resolution for low frequencies. Thus, WT is a good tool to extract local features of the image and thus is used to extract minutiae of the fingerprint image.



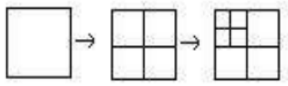
(a) (b)

Figure 5. Core point localization
(a) Orientation Image (b) Detected Core Point

The hierarchical wavelet transform uses a family of wavelet functions and its associated scaling functions to decompose the original signal/image into different sub bands. The decomposition process is recursively applied to the sub bands to generate the next level of the hierarchy.



This shows one level DWT. At every iteration of the DWT, the lines of the input image (obtained at the end of the previous iteration) are low-pass filtered and high pass filtered. Then the lines of the two images obtained at the output of the two filters are decimated with a factor of 2. Next, the columns of the two images obtained are low and high pass filtered. The columns of those four images are also decimated with a factor of 2. Four new sub-images (representing the result of the current iteration) are generated. The first one, obtained after two low-pass filtering, is named approximation sub-image (or LL image). The others three are named detail sub-images: LH, HL and HH. The LL image represents the input for the next iteration.



In this paper we have used level 2 daubechies transform and only the second level LL image is used for the analysis as that contains most of the important texture information. Daubechies deals with problems associated with JPEG compression and random additive noise.

6. Conclusion

Although many minutiae point pattern matching algorithms have been proposed, it has drawbacks for low quality images. Depending on the quality of the fingerprint several false minutiae may come out. The proposed approach is very simple compared to minutia point pattern matching algorithm. It is robust as DWT is rotation invariant transform. We use FVC2000 database. FVC2000 is a popular and public fingerprint image database; however, many of its fingerprint images are damaged by local image noise. According to the core point location, fingerprint type can be classified and continue to local feature matching using Euclidean Distance matric.The effectiveness of the proposed method can be confirmed through the experimental results. Our proposed system can identify the low quality fingerprint image and get high accuracy and low complexity.

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