Personal Identification System Based on Fingerprint features

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Abstract

Fingerprint-based identification is one of the core methodologies for personal identification. It remains a reliable, efficient and commonly accepted biometric. We propose a fingerprint recognition system for identifying the low quality fingerprint images from inked-printed images on paper. Traditional minutia based approach is not robust to poor quality fingerprint images. In proposed system, the texture-based approach for fingerprint recognition using Discrete Wavelet Transform (DWT) is developed. The input image is preprocessed and gabor filtering is applied for ridge line enhancement. The system finds the local features of the fingerprint using DWT and it is compared to the database using Euclidean distance metric. We trained 150 images and obtained an overall performance up to 95%.The effectiveness of the proposed system can be confirmed through the experimental results.

***Keyword**:* fingerprint recognition, Discrete Wavelet Transform, gabor filter

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].
Biometrics is a rapidly evolving technology that has been widely used in forensics, such as criminal identification and prison security, and has the potential to be widely adopted in a very broad range of civilian applications such as Banking security, Physical access control, Information system security, customs and immigration. Fingerprint is the most reliable bio-metric for people identification [2].

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 from the fingerprint image. Fingerprint can be grabbed using inked impression on a paper or sensors.

Several methods of automatic fingerprint identification have been proposed in the literature. Minutiae based approach often gives satisfactory results for good quality images. But if, the quality of the image is poor, then minutiae extraction is a very difficult task and often gives incorrect results that are not acceptable for real time authentication applications. The minutiae sets may suffer from false, missed, and displaced minutiae, caused by poor fingerprint image quality and imperfections in the minutiae extraction stage [6].

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. The 2D wavelet decomposition on J octaves of the image is used as the feature for recognition [3]. These approaches require less preprocessing or post processing effort than minutiae-based methods. While minutiae-based methods normally require a minutiae location process [4] [5], image-based methods match two fingerprint images directly, based on their texture features. The general overview of the fingerprint identification system is as shown in Figure 1.

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. We apply DWT to extract local features and matching is done using Euclidean distance metric. The proposed system can recognize not only the fingerprint acquired from device but also the low quality fingerprint image from inked-printed images on paper.

The rest of the paper is organized as follows: section 2 reports related works. In section 3 and 4, the overview of the proposed system and the preprocessing of fingerprint image are described. Section 5 and 6 present discrete wavelet transform and feature extraction. Section 7 is experimental results. Finally, in section 8, the concluding remarks are given.

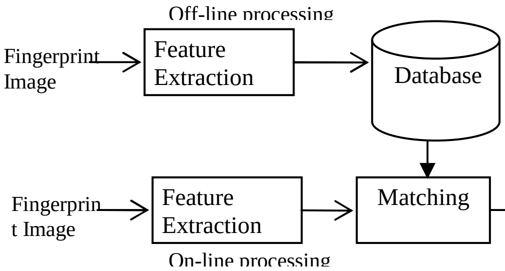


Figure 1.Overview of Fingerprint Identification

2. Related Works

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 [7] proposed descriptor-based minutiae matching algorithm emphasis on minutiae descriptors and the computation of matching scores. The work presented in S.LinLin [6] 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 [8] 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 2.

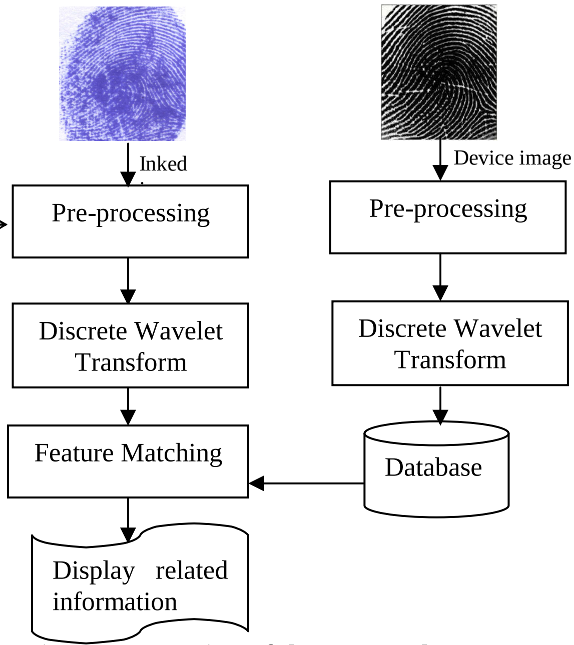


Figure 2. Overview of the Proposed System

In proposed system, for registering the fingerprints, the fingerprint images acquired from fingerprint device are used. The fingerprints used to train by using the proposed are acquired by fingerprint device (Hamster Eye-D). For the identification stage, the inked images scanned from printed paper are used. For both the registration and identification stages, the following processing steps are performed. Firstly, image enhancing step is performed. Then, the orientation flows are detected and gabor filters is applied for fingerprint ridge enhancement. DWT is applied for extracting the fingerprint features and feature matching is performed to database using Euclidean distance metric. If the input image matches with the one from the database, the information of the matched person is displayed.

4. Preprocessing

Image preprocessing includes gray scale converting, orientation estimation and enhancement by using gabor filter.

It is well known that image enhancement is a very important task for extracting reliable features, especially on poor quality fingerprints, and reliable estimation of local orientations is a fundamental prerequisite for a good image enhancement. Reliable orientation extraction in low-quality regions is still an open problem and new approaches are often proposed in the literature. In proposed system, gradient based approach is used for extraction of ridge direction. The following steps are applied for finding orientations (Hong et al., 1998).

Let θ be defined as the orientation field of a fingerprint image. *θ(x,y)* is the least square estimate of the local ridge orientation at the block centered at pixel *(x,y)*. Firstly, divide the fingerprint image into no-overlapping blocks of size *w*x*w*.

Compute the gradients $\partial_x(x,y)$ and $\partial(x,y)$ of each pixel *(x,y)* corresponding to the horizontal and vertical directions. The Sobel operator is employed in this work.

The local orientation of the (*x*,*y*) centered *w*x*w* sized block is calculated by:

$$V_y(x,y)=\sum_{u=x-W/2}^{x+W/2}\sum_{v=y-W/2}^{y+W/2}2\partial_x(u,v)\partial_y(u,v) \quad (1)$$

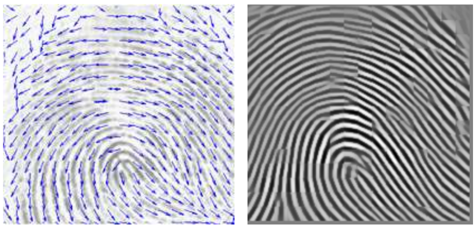
$$V_x(x,y)=\sum_{u=x-W/2}^{x+W/2}\sum_{v=y-W/2}^{y+W/2}\partial^2{}_x(u,v)-\partial^2{}_y(u,v) \quad (2)$$

$$\theta(x,y)=\frac{1}{2}\tan^{-1}\frac{V_y(x,y)}{V_x(x,y)} \quad (3)$$

The ridges and valleys in a small local neighborhood have well defined local frequency and local orientation properties [9]. A set of band pass filters can remove the undesired noise and preserve true ridge structures. Gabor filters have both frequency-selective and orientation-selective properties and have optimal joint resolution in both spatial and frequency domains. Gabor filters are used to remove the noise and preserve true ridge/valley structures. The filter applied at each pixel [*x*, *y*] has the form:

$$g(x,y:\theta,f)=e^{\left(\frac{-(x+y)^2}{2\delta^2}\right)}\cos[2\pi.f.(x.\sin\theta+y.\cos\theta)] \quad (4)$$

where θ and f are the corresponding local orientation and frequency. To reduce the complexities and memory spaces, thinning process is performed for filtered fingerprint image. Two pass thinning approach is applied for this stage. The results of ridge orientation and gabor filtered images are shown in Figure. 3.



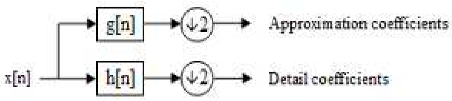
(a) (b)

Figure 3(a) Orientation field image (b) filtered image

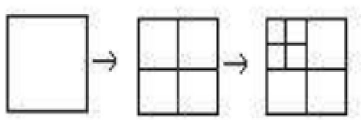
5. Discrete Wavelet Transform

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.

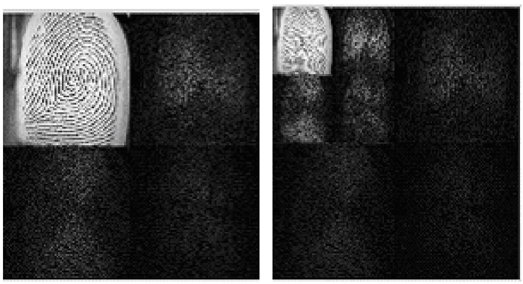
The hierarchical wavelet transform uses a family of wavelet functions and its associated scaling functions to decompose the original signal/image into different sub bands. The decomposition process is recursively applied to the sub bands to generate the next level of the hierarchy.



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.



The one level DWT and two level DWT fingerprints are shown in Figure 4.



(a) (b)

Figure 4. Wavelet Decomposition (a)One level DWT (b) two level DWT

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. Feature Extraction

Feature extraction is concerned with the quantification of texture characteristics in terms of a collection of descriptors or quantitative feature measurements, often referred to as a feature vector. Feature extraction with DWT starts the input image to 2-level discrete wavelet transform decomposition. At each level, the wavelet transform decompose the given image in to three directional components, i.e., horizontal, diagonal and vertical detail sub bands in the direction of 0, 45 and 135 respectively apart from the approximation (or) smooth sub band. For the second level LL sub-image compute the following three features.

i. Standard deviation:

The standard deviation of the image gives a measure of the amount of detail in that sub band.

ii. Kurtosis:

It measures the peaked ness or flatness of the distribution and is given by

$$k = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{x_i - \mu}{\delta}\right)^4 \qquad (5)$$

where μ is the sample mean of the N pixels within the image and σ is standard deviation.

iii. Skewness

Skewness is a measure of the asymmetry of the data around the sample mean.

$$g_1 = \frac{m_3}{m_2^{3/2}} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^{3/2}} \qquad (6)$$

where, X_i is the i^{th} value, $\bar{\chi}$ is the sample mean, m_3 is the sample third central moment, and m_2 is the sample variance.

Given samples from a population, the equation for the sample skewness g1 above is a biased estimator of the population skewness. A distribution that is skewed to the left (the tail of the distribution is heavier on the right) will have a negative skewness. A distribution that is skewed to the right (the tail of the distribution is heavier on the left), will have a positive skewness.

In the feature matching phase, the texture feature set for the test sample *X* is computed using the proposed algorithm. The feature database of texture classes k prepared during training phase is used to compare the feature of test image. The distance metric can be termed as similarity measure. The distance between the texture classes stored in database and the test image is computed and used for classification. The test image is more similar to database class if the distance is smaller. The test image is recognized to belong to one of the classes of the database, if the smallest distance between the test image and texture classes is lesser than a threshold value. If the smallest distance is not lesser than the fixed threshold then the test image doesn't belong to any of the texture classes. If N is the number of features in feature set f, $f_j(x)$ is the j^{th} texture feature of the test sample X and $f_j(k)$ is the j^{th} texture feature of k^{th} texture class in the database, then the Euclidean distance metric is described as below:

$$d_E(k) = \sqrt{\sum_{j=1}^{N}\left[f_j(x) - f_j(k)\right]^2} \quad (7)$$

7. Experimental Results

The proposed system has been evaluated on the fingerprint database captured from Hamster Eye-D fingerprint device. This database consists of 150 fingerprints of 50 individuals (3 images per finger) and the image of the database is the size 256 × 256. DWT is used as the analysis tool. Daubechies wavelet is used as the mother wavelet. Two level db10 is used. All three features are calculated for each image. The average value of each feature for each individual is used for classification. This value is compared with the test image's features using Euclidean distance measures. The classification performance is the rate of correct classification of surface textures. From the experiments, the best results were achieved using the proposed system. The proposed system gives the overall performance of correct classification as 94.28%.

The experimental analysis was performed in MATLAB 7.10 and run using Intel core2 duo CPU E7500 with 2.93 GHz and 1.98 GB RAM.

8. Conclusion

The finger print recognition system for the low quality image is presented in this paper. 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. Our proposed system can identify the low quality fingerprint image and get high accuracy and low complexity.

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