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Fingerprint Recognition Using Wavelet Transform

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ABSTRACT

Fingerprint verification is one of the most reliable personal identification methods and it plays a very important role in forensic and civilian applications. Security systems are now computerized. Automated security systems are essential now. These days most of the banking transactions, use of cell phones and personal digital assistants (PDAs) are frequently performed. However, manual fingerprint verification is so tedious, time-consuming, and expensive in that it is incapable of meeting today's increasing performance requirements. Hence, an automatic fingerprint identification system (AFIS) is widely needed. Wavelet transform which has wide range of applications such as image compression, denoising noisy data, texture classification, etc., is used in this paper, for Fingerprint verification. In this work, a fingerprint recognition system has been developed which is based on the texture pattern of the fingerprint. In the proposed approach, features are extracted directly from the original image without preprocessing, thus are computationally efficient. Implementation is done on MATLAB R2007b as the programming tool.

Keywords- Fingerprint, Security, Wavelet, texture.

I. INTRODUCTION

Accurate automatic personal identification is becoming more and more important to the operation of our increasingly electronically interconnected information society. Traditional automatic personal identification technologies to verify the identity of a person, which use "something that you know," such as a personal identification number (PIN), or "something that you have," such as an identification (ID) card, key, etc., are no longer considered reliable enough to satisfy the security requirements of electronic transactions.

Biometrics is a rapidly evolving technology which uniquely identifies a person based on his/her physiological or behavioural characteristics such as finger prints, hand geometry, iris, retina, face, hand vein, facial thermo grams and voice print [1]. Among all biometric indicators, finger prints have one of the highest level of reliability [2, 3] and have been extensively used by forensic experts in criminal investigations [4].

The fingerprints are classified based upon their characteristics. (i) Latent fingerprints: The accidental impressions left by ridge on a surface, regardless of whether it is visible or invisible at the time of deposition. (ii) Patent fingerprints or visible fingerprints: The impressions caused by the transfer of ink materials on the finger onto a surface. (iii) Impressed fingerprints: The impression from a finger deposited on a material that retains the shape of the ridge details. The impression captured using scanner is for fingerprint identification and verification [5].

There are many methods to extract and match fingerprint features and can be classified into three categories: minutiae-based, correlation-based, and hybrid [6]. Minutiae-based techniques attempt to align two sets of minutiae points from two fmgerprints and count the total number of matched minutia [7, 8]; the performance of minutiae-based techniques relies on the accurate detection of minutiae points as well as the use of sophisticated matching techniques to compare two minutiae fields that undergo non-rigid transformations. In the correlation-based approach, global patterns of ridges and furrows are compared to determine whether two fingerprints align [9, 10]; the performance of correlation based techniques is affected by non-linear distortions and noise present in the image. Finally, in hybrid methods, local orientation and frequency, ridge shape, and texture information are used to extract fingerprint features [11], the robustness of hybrid methods is affected by the difficulty of detecting all minutiae. Moreover, the computational requirements are very high. All these operations require vast of computer resources and time and cannot be implemented in small computer systems.

This work is focused on finding the solutions of such problems to develop a low cost, and small module fingerprint identification system based on wavelet based pattern recognition techniques.

II. RELATED WORK

In the field of fingerprint identification, different types of work have been done so far. We had gone through various research papers.

Avinash Pokhriyal and Sushma Lehri [12], Proposed an algorithm of fingerprint verification based on wavelets and pseudo Zernike moments. Wavelet was used to denoise and extract ridges. The pseudo Zernike moments was used to extract features which carry the descriptive information about the fingerprint image.

Zhang quinghui and Zhang Xiangfie [13], Proposed the algorithm for fingerprint Identification. Fingerprint image pretreatment processes like gamma controller standardization, Directional diagram computation, image filtering, binarization processes and image division were applied for improving the image quality.

M Dadgostar et al., [14], presented a fingerprint identification method where features were extracted using Gabor filter and recursive Fischer linear discriminant. The fingerprint image was decomposed into several windows of 32×32 pixels and normalized using mean and variance. Using Gabor filter in different orientations features were extracted. To reduce the high dimensional features, recursive Fischer linear discriminant was applied to extract more discriminant features. Classifications being achieved using Nearest Cluster Centre classifier with leave one out method and 3NN classifier.

Nae myo [15], Presented the algorithm of multilayer convex polygon for fingerprint Identification. The fingerprint image was subjected to enhancement and segmentation for noise removal. Using computational geometry algorithms multiple convex layers were created. Among the entire layers smallest polygon was considered. An ellipse which covers the smallest polygon and its all points was considered. The reference polygon and the area ratio have been extracted for matching.

Bhupesh Gour et al., [16], presented ART1 clustering algorithm and Modular neural network for fingerprint recognition. The data base of fingerprint was classified into number of classes by using ART1 clustering algorithm. The monolithic neural network and Back propagation algorithm was used to train the entire fingerprint in the data base. The test fingerprint was compared with the class to which the test fingerprint belongs to. The fingerprint recognition was performed by both monolithic and modular neural network and their performance being compared.

V Conti et al., [17], proposed algorithm of finding singularity points for efficient fingerprint classification. The method extracts the singularity points like core, delta and pseudo singularity points using poincare indexes to achieve classification. Hamming distance was used for matching score. The single rotation matching are the two algorithms used for matching.

S.S.Gornale et al., [18], presented an algorithm based on discrete wavelet transform (DWT) for image de-nosing. The time invariant properties of un-decimated discrete wavelet transforms were used for de-noising the image. The use of wavelet transforms omits both down-sampling in the forward and up sampling in the inverse transform.

III. INTRODUCTION

In this work, the whole fingerprint identification system includes feature extraction and matching processes. The fingerprint identification system includes enrolment module and identification module. Enrolment module involves the storage of fingerprint images into database, while the identification module processes the input fingerprint image, compares it with the fingerprint images from database and matches it to the correct fingerprint image from database.

Figure 3.1 shows the processes in both the enrolment module and identification module.

Both of the enrolment module and identification module have feature extraction process. In this process, after finding the core point of the fingerprint image, images of size 64 x 64 pixels are cropped around the core point. Cropped 64 x 64 pixels image is divided into four non overlapping equal parts. Afterwards, the resulted each part image goes through wavelet transform in order to produce three directional images (Horizontal, Vertical and Diagonal). From each wavelet transformed image, texture features are calculated.

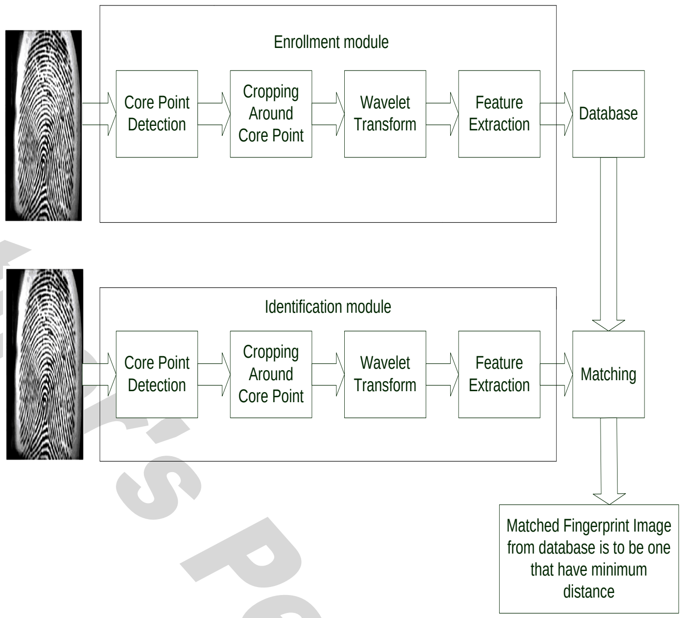


Figure 3.1. The Processes involved in the Fingerprint Identification System

For each stage of wavelet transform, the size of image is reduced to its half of the original size. Hence, the wavelet transform process can save the database space. The combined texture features from 64 x 64 pixels images are used to store in the database.

Cropping-The step after locating core point is to crop the image with size 64 x 64 pixels. The cropped 64 x 64 pixels image after core point location is shown in figure 3.2. Cropping is used to standardize the image that later is used for matching process.

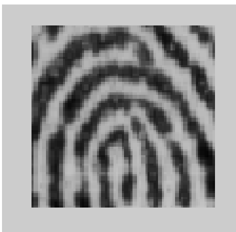
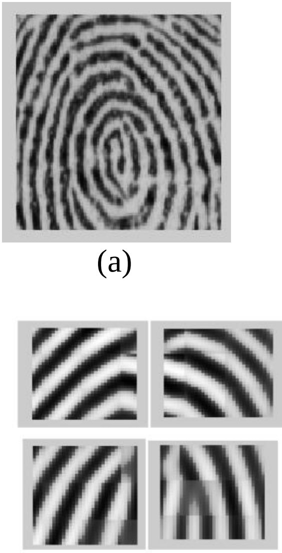


Figure 3.2. Cropped 64 x 64 pixels image

Fingerprint Distinctive Region-Cropped fingerprint image (64 x 64 pixels) is divided into four non overlapping equal parts (32 ×32 Pixels) after finding the core point from the original image. These four parts images are the fingerprint distinctive regions that are used for the further processing.

Wavelet Signatures:

Energy Signatures: The wavelet energy signatures reflect the distribution of energy along the frequency axis over scale and orientation. They have proven to be very powerful for texture characterization. Energy signatures are defined as



(a)

(b)

Figure 3.3. (a) Cropped 64 x 64 pixels image
(b) Four 32 x 32 pixels sub images quartered at center

$$M = \frac{1}{N \times N} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} b(i, j)$$

$$S = \sqrt{\frac{1}{N \times N} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (b(i, j) - M)^2}$$

$$Energy(e) = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} b(i, j)^2$$

Where b (i , j) , represents the pixel values of decomposed sub images at coordinates (i ,j), N× N is the size of decomposed sub image, M is the mean of sub image, S is the standard deviation of sub image and E is the energy of sub image.

Feature Matching: Euclidean distance is used to compute the matching score between test image and database images. Test fingerprint image will be more similar to the database fingerprint image if distance between them is smaller. Euclidean distance is given by equation

$$d = \sqrt{\sum_{j=1}^{N} (F_i - F_j)^2}$$

where F_i, F_j are feature vectors of database image and test image respectively.

Genuine Accept Rate (GAR):

The probability that an authorized person is correctly accepted as authorized person. It measures the recognition accuracy of the system.

GAR= (True claims accepted/Total true claims) ×100 %

False Accept Rate or False Match Rate (FAR or FMR):

The probability that an unauthorized person is correctly accepted as authorized person. It measures the percent of invalid inputs which are incorrectly accepted.

FAR= (Imposter claim accepted/Total imposter claims)×100 %

False Rejection Rate or False Non-Match Rate (FRR or FNMR):

The probability that the system fails to accept an authorized match. It measures the percent of valid inputs which are incorrectly rejected.

FRR = (True claims rejected/Total true claims) × 100 %

IV. PERFORMANCE ANALYSIS

The accuracy verification in biometrics is measured by the Percentage Recognition Rate. In order to test the performance of the fingerprint identification system, fingerprint images from database of FVC 2002 were used. 20 fingerprint images were chosen from the FVC 2002 database, where the 20 fingerprint images were from 5 peoples, 4 impressions were taken from each person.

For the first testing, the system is trained with single image of each user and the input fingerprint images were same as the 5 fingerprint images that stored in database. The input fingerprint images were loaded into the fingerprint identification system for the verification purpose. The total of correctly matched percentage is 100%.

For the second testing, the system is trained with single image of each user, the 4 fingerprint impressions from each person were loaded into the fingerprint identification system for verification. However, the total of the correctly matched percentage was 95 %.

Table 4.1. Accuracy Table for different methods

TS	DCT	TRADITIONAL FFT	FRIRV	WAVELET BASED
TS=2	71.25%	73.75%	80%	95%
TS=1	95%	100%	100%	100%

From table it is observed that Wavelet Energy Signatures (Daubechies 10) outperforms the DCT, FFT AND FRIRV based algorithms.

V. CONCLUSION

The work explored the use of wavelet transform to reduce the size of fingerprint images with less pre-processing and post-processing operations which made the system simple and less space and time consuming. It has also explored the use of new feature vector wavelet co-occurrence signatures to match the database fingerprint images with the input fingerprint images using Euclidian distance. This method is more efficient, than previous techniques of fingerprint recognition because wavelet transform reduced the size of fingerprint and the use of wavelets directional resolving power in horizontal, vertical and diagonal direction of the fingerprint image increases the recognition rate. So, the fingerprint identification system developed during the work has proved to be a cost effective algorithm in both time and space, with a good level of accuracy.

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