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Fingerprint Verification using Statistical and Co-Occurrence Matrix Features

Shweta Ujwal Bagadi, Giridhar P. Jain

Abstract— ***Fingerprint identification is one of the most well-known and publicized biometrics. Because of their uniqueness and consistency over time, fingerprints have been used for identification for over a century, more recently becoming automated (i.e. a biometric) due to advancement in computing capabilities. Fingerprint identification is popular because of the inherent ease in acquisition, the numerous sources (ten fingers) available for collections, and their established use and collections by law enforcement and immigration. Fingerprint verification is one of the most reliable personal identification method and it plays a very important role in forensic and civilian applications. However, manual fingerprint verification is so tedious, time-consuming, and expensive that it is incapable of meeting today's increasing performance requirements. Hence, an automatic fingerprint identification system (AFIS) is widely needed. Proposed system describes the design and implementation of an off-line fingerprint verification system using wavelet transforms. In this method, matching is done between the input image and the stored template without resorting to exhaustive search using the extracted feature.***

Keywords—***fingerprint verification, wavelet transform, automatic fingerprint identification system (AFIS),***

I. INTRODUCTION

Accurate automatic personal identification is becoming more and more important to the operation of our increasingly electronically inter-connected information society. Traditional automatic personal identification technologies, which are in use such as Personal Identification Number (PIN), ID card, key, etc., to verify the identity of a person, are no longer considered reliable enough to satisfy the security requirements of electronic transactions. All of these techniques suffer from a common problem of their inability to differentiate between an authorized person and an impostor who fraudulently acquires the access privilege of the authorized person. Biometrics is a rapidly indicators have an edge over traditional security methods in which information cannot be easily stolen or shared. Among all biometric indicators, finger prints have one of the highest levels of reliability and have been extensively used by forensic experts in criminal investigations. A finger print can be viewed as an oriented texture pattern.

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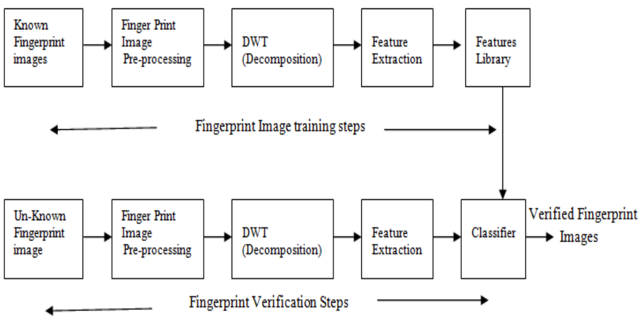
Jain et al. show that for sufficiently complex oriented texture such as finger prints, invariant texture representations can be extracted by combining both global and local discriminating information in the texture which forms the basis of proposed work. Firstly, the Discrete Wavelet Transform (DWT) features are used for Fingerprint characterization and verification. Secondly, the co-occurrence features computed out of the sub bands of wavelet transformed images are used for fingerprint verification. This is done as the chances of correct verification will be considerably improved if higher order statistical features are used, as they will normally have good discriminating ability than the lower order one. Fingerprint image's, statistical features such as mean and standard deviation are extracted from the approximation and from the detail regions of DWT decomposed images, at different scales. The various combinations of the above statistical features are applied for fingerprint verification and a set of best feature vectors are chosen. In order to improve the success rate of verification, the co-occurrence matrix is calculated for original image, approximation and detail sub-bands of 1- level DWT decomposed images and additional features are extracted. These additional features are combined with the above chosen best wavelet statistical feature sets for verification.

II. PROPOSED SYSTEM

The objective of the proposed work is to extract the statistical & co-occurrence features of fingerprint image using Discrete Wavelet Transform & compare them with the stored features for verification. Fig.1 shows the system block diagram of proposed work. The whole work is implemented in two steps, fingerprint template making and fingerprint verification. Initially the known test database is used to extract the features and to create the feature library. Further from the unknown fingerprint images, the features are extracted and compared with the features stored in the library for verification. In order to improve the correct verification rate, further, it is proposed to find co-occurrence matrix features as mentioned in detail below in the proposed process.



A. *Details of Proposed Process*

In the proposed work the process of fingerprint verification is subdivided into a number of processing modules which can be identified as:

- Data acquisition
- Pre-processing
- Feature Extraction
- Comparison and Verification

1) Data Acquisition: With the help of optical sensors fingerprint images are extracted for generating the database. The database is further divided into two groups for training and for testing process. These will be further used for pre-processing and finally feature extraction is done using wavelet transform.

2) Fingerprint Image Pre-Processing: Fingerprint Image enhancement is done to make the image clearer in order to make further operations easy. Since the fingerprint images acquired from sensors or other medias are not assured with perfect quality, the enhancement methods, for increasing the contrast between ridges and furrows , for connecting the false broken points of ridges due to insufficient amount of ink, are very useful to keep a higher accuracy in fingerprint recognition. Two Methods are adopted in fingerprint recognition system: the first one is Histogram Equalization; the next one is Fourier Transform. Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptional information. The original histogram of a fingerprint image has the bimodal type as shown in Fig. 2 and the histogram after the histogram equalization occupies all the range from 0 to 255 as shown in Fig. 3 and the visualization effect of an image is enhanced as shown in Fig. 4. [18]

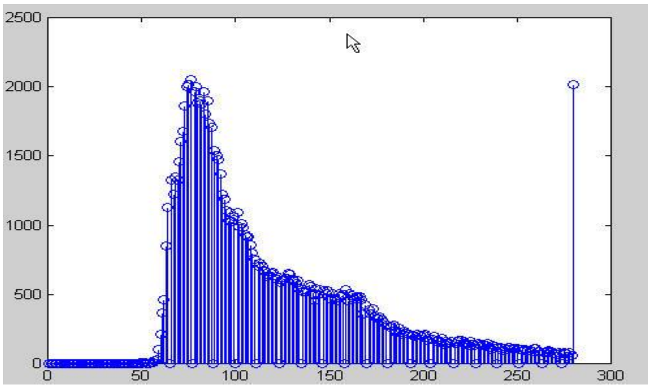


Fig. 2 Original histogram of a fingerprint image

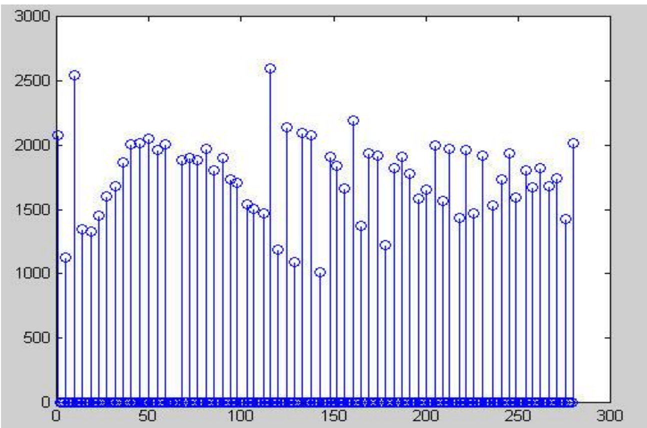


Fig. 3 Histogram after equalization

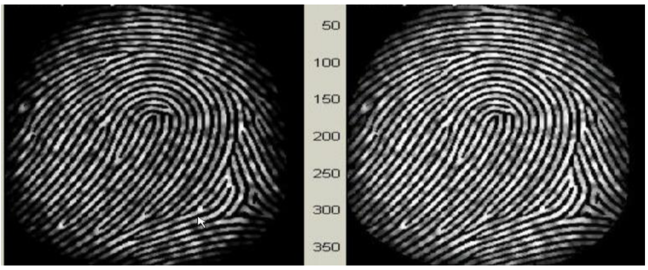


Fig. 4 Histogram Enhancement.
Original Image (Left), Enhanced image (Right)

In the Fingerprint Enhancement by Fourier Transform method the image is divided into small processing blocks (32 by 32 pixels) and the Fourier transform is performed according to equation (1).

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

For $u = 0, 1, 2, ..., 31$ and $v = 0, 1, 2, ..., 31$.

In order to enhance a specific block by its dominant frequencies, we multiply the FFT of the block by its magnitude a set of times. Where the magnitude of the original FFT equals abs (F (u, v)) which equals |F(u, v)|. Enhanced block is obtained according to equation (2).

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

where $F^{-1}(F(u,v))$ is obtained by equation (3).

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

for $x = 0, 1, 2, ..., 31$ and $y = 0, 1, 2, ..., 31$.

The k in equation (4) is an experimentally determined constant, which we choose k=0.45 to calculate. While having a higher "k" improves the appearance of the ridges, filling up small holes in ridges, having too high a "k" can result in false joining of ridges. Thus a termination might become a bifurcation. Fig. 5 presents the image after FFT enhancement. Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black colour while furrows are white.

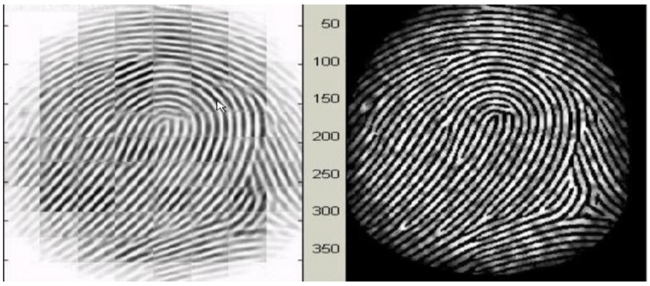


Fig. 5 Fingerprint enhancement by FFT
Enhanced image (left), Original image (right)

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In general, only a Region of Interest (ROI) is useful to be recognized for each fingerprint image. Thus image segmentation is done. The image area without effective ridges and furrows is first discarded since it only holds background information. Then the bound of the remaining effective area is sketched out since the minutias in the bound region are confusing with those spurious minutias that are generated when the ridges are out of the sensor.

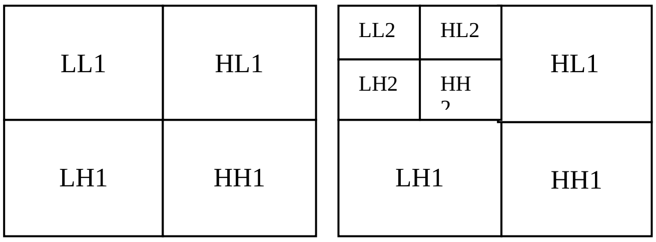
3) Feature Extraction: Feature extraction is done in both fingerprint template making and as well as during fingerprint verification. The steps involved in Fingerprint template making and Fingerprint verification are as mentioned below. In the fingerprint template making , the known fingerprint images are decomposed using DWT (Daubechies-tab 4 filter). For decomposition-Mallat Tree Decomposition Algorithm is used. Then, the wavelet statistical features such as mean and standard deviation of approximation are extracted using the formulas given in the Eqns. (4) and (5) respectively and stored in features library.

Mean (m) = $\frac{1}{N^2}\sum_{i,j=1}^{N} p(i,j)$ ----- (4)

Standard Deviation (sd) = $\sqrt{\frac{1}{N^2}\sum_{i,j=1}^{N}[\, p(i,j) - m]^2}$ ------ (5)

where p (i, j) is the transformed value in (i, j) for any sub-band of size N x N.

The Discrete Wavelet Transform (DWT) is identical to a hierarchical sub band system where the sub bands are logarithmically spaced in frequency and represent octave-band decomposition [7].The image is actually decomposed i.e., divided into four sub bands and critically sub sampled by applying DWT as shown in Fig. 6(a). These sub bands labelled LH1, HL1 and HH1 represent the finest scale wavelet coefficients i.e., detail images while the sub band LL1 corresponds to coarse level coefficients i.e., approximation image. To obtain the next coarse level of wavelet coefficients, the sub band LL1 alone is further decomposed and critically sampled. This results in a two-level wavelet decomposition as shown in Fig. 6(b).



(a) One- level **(b) Two-level**

Fig. 6 Image Decomposition

Similarly, to obtain further decomposition, LL2 will be used. This process continues until some final scale is reached. The features obtained from these wavelet transformed images are used for fingerprint verification and identification. Detail sub-bands of three level decomposed images (i.e., LLk, LHk, HLk and HHk; for k=1, 2, 3) are calculated as features. Using this procedure, from any fingerprint image, the features (upto k-level sub-bands) are computed and stored in the features library which are further used in fingerprint verification phase. In order to improve the correct verification rate, further, it is proposed to find co-occurrence matrix features for detail sub-bands of 1-level DWT decomposed images (i.e., LL1, LH1, HL1 and HH1), called wavelet co occurrence features. The various co-occurrence features such as contrast, energy, entropy, local homogeneity, cluster shade, cluster prominence and maximum probability, are calculated from the co-occurrence matrix C(i,j) using the equations mentioned below.

Energy = $\sum_{i,j=1}^{N} C^2\,(i,j)$ ------(6)

Entropy = $-\sum_{i,j=1}^{N} C(i,j)\log_2 C(i,j)$ ------(7)

Local Homogeneity = $\sum_{i,j=1}^{N}\frac{1}{1+(i-j)^2}\, C(i,j)$ ------(8)

4) Fingerprint Comparison and Verification : Here, the fingerprint images, is decomposed using DWT and a similar set of wavelet statistical and co-occurrence matrix features are extracted and compared with the corresponding feature values stored in the features library using a distance vector formula, given in equation (9).

D(i) = $\sum_{j=1}^{No\ of\ features} abs[\, f_j(x) - f_j(i)\,]$ -----(9)

Where fj(x) represents the features of unknown fingerprint while fj(i) represents the features of known ith fingerprint in the library. Then, the unknown fingerprint is verified as ith fingerprint, if the distance D(i) is less than or equal to the threshold value among all fingerprints, available in the library

5) Results and Discussions: We have developed Fingerprint Verification system using wavelet transform .We have used 400 fingerprint samples of 50 people 8 sample of each people. These 200 samples of fingerprint we are using for training or creating database(i.e first 4 sample 1,2 3,4 fingerprint images as a template in database) and remaining 200 samples(i.e. last 4 samples 5,6,7,8 we are using for fingerprint Verification/Matching/ testing.

Concept of Threshold setting:- step1: For the given test sample Fingerprint image we are finding the Euclidean Distance between the stored features of all template samples and the extracted features of test

Step1:- We are calculating the Euclidean distance vector of test fingerprint image with all training fingerprint images.

Step2:- After calculating ,we are sorting Euclidean Distances and finding the maximum value.

Step3: The Threshold is set as 9% of Max (Euclidean Distances) [10]

Fingerprint Verification Techniques	Verification Rate
1) Fingerprint Verification System using Minutiae Extraction Technique [16]	75%
2) Fingerprint Recognition Using Minutiae Score Matching [17]	77%
3) Fingerprint Verification Using Wavelet Transform (Rotation Independent) [14]	93.33%
4) The Proposed method , " Fingerprint Verification using statistical and co-occurence matrix features"	84.5%

III. Application

The results of the study will be useful in recognizing a person using wavelet features of Fingerprint image.

1. Licence office
2. Crime Branch
3. Voter Identification
4. For Attendance purpose etc.

IV. Future Scope

Various combinations of feature extraction methods along with the different classifying engine can be used to enhance the accuracy and the performance of the system.

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