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A LOW COST FINGERPRINT RECOGNITION SYSTEM BASED ON WAVELET TRANSFORM

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Abstract— *Fingerprint technique is used for identification and verification purposes as it develops a low cost and fast computing system. There are many approaches for fingerprint recognition. The two basic approaches for fingerprint identification are minutiae based approach and Pattern recognition approach. Now a day's wavelet based approach is most preferred due to its time-frequency. We are presenting here this new Wavelet based approach and compare the results by Traditional DFT, Traditional FFT, FRIRV techniques.*

Keywords— *Fingerprints, Wavelets Transform, Pattern, Texture.*

I. INTRODUCTION

Fingerprints have been an invaluable tool for law enforcement and forensics for over a century, motivating research into automated fingerprint-based identification in the early 1960s common and reliable biometric for automatic personal identification is fingerprint. Indeed, due to their uniqueness and unchangeability, fingerprints have widely used by many police agencies as a trusted biometric for personal identify localization. However, the fingerprint recognition that aims to find a match for a probe fingerprint in the database of enrolled prints is extremely long because of an enormous number of personal records in the database (e.g. there are more than millions of US's criminal records). Classification can help to accelerate the fingerprint recognition. An automatic fingerprint classification method aims to enhance the fingerprint images, to identify appropriate features, to extract these features and finally to classify the fingerprints based on these features. Consequently, the time for the matching task is significantly reduced. Biometrics is a rapidly evolving technology which uniquely identifies a person based on his/her physiological or behavioral characteristics such as finger prints, hand geometry, iris, retina, face, hand vein, facial thermo grams and voice print [1]. Biometrics has been widely used in forensics 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, government benefits distribution, customs and immigration, national ID systems, and voter and driver registration. The above bio metric indicators have an edge over traditional security methods in that these methods can not be easily stolen or shared [2]. Among all biometric indicators, finger prints have one of the highest level of reliability [3] [4] and have been extensively used by forensic experts in criminal investigations [5].

II. RELATED WORK

One approach uses record characteristics of the ridges and stores this information for classification. Fingerprint image enhancement algorithm based on contextual filtering in the Fourier domain. The proposed algorithm is able to simultaneously yield the local ridge orientation and ridge frequency information using short time Fourier analysis [7]. The algorithm is also able to successfully segment the fingerprint images. The following are some of the advantages of the proposed approach

- (1) The proposed approach obviates the need for multiple algorithms to compute the intrinsic images and replaces it with a single unified approach.
- (2) This is also a more formal approach for analysing the non-stationary fingerprint image than the local/windowed processing found in literature.
- (3) The algorithm simultaneously computes the orientation image, frequency image and the region mask as a result of the short time Fourier analysis. In most of the existing algorithms the frequency image and the region mask depend critically on the accuracy of the orientation estimation.
- (4) The estimate is probabilistic and does not suffer from outliers unlike most maximal response approaches found in literature.

In this algorithm the image is divided into overlapping windows. It is assumed that the image is stationary within this small window and can be modeled approximately as a surface wave. The Fourier spectrum of this small region is analyzed and probabilistic estimates of the ridge frequency and ridge orientation are obtained. The STFT analysis also yields an energy map that may be used as a region mask to distinguish between the

fingerprint and the background regions. The orientation image is then used to compute the angular coherence [8]. The coherence image is used to adapt the angular bandwidth. The resulting contextual information is used to filter each window in the Fourier domain [9]. The enhanced image is obtained by tiling the result of each analysis window. The performance of a fingerprint feature extraction and matching algorithms depend heavily upon the quality of the input fingerprint image. We presented a new Fingerprint image enhancement algorithm based on STFT [10] analysis and contextual/nonstationary Filtering in the Fourier domain. The algorithm has several advantages over the techniques proposed in literature such as

- (i) All the intrinsic images (ridge orientation, ridge frequency, region mask) are estimated simultaneously from STFT analysis. The estimation is probabilistic and is therefore more robust.
- (ii) The enhancement utilizes the full contextual information (orientation, frequency, angular coherence) for enhancement [11].
- (iii) The algorithm has reduced space requirements compared to more popular Fourier domain based filtering techniques.

The improvement in matching accuracy for poor quality prints. We show that it results in 24.6% relative improvement in recognition rate over a set of 800 images in FVC2002 DB3 [12] database. Our future work includes developing a more robust orientation smoothening algorithm prior to enhancement.

III.STATE OF THE ART IN FINGERPRINT RECOGNITION

Fingerprint identification is based upon unique and invariant features of fingerprints. Fingerprints are graphical flow like ridges present in human fingers which are formed during embryonic development, caused by ridges underneath the skin. According to FBI, the odds of two people sharing the same fingerprints are one in 64,000,000,000. Fingerprints differ even for ten fingers of the same person.



Fig. 1 Fingerprint Images

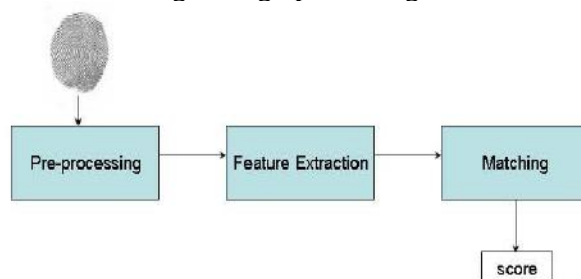


Fig. 2 Modules of fingerprint recognition

The main modules of a fingerprint verification system are: a) fingerprint sensing, in which the fingerprint of an individual is acquired by a fingerprint scanner to produce a raw digital representation; b) preprocessing, in which the input fingerprint is enhanced and adapted to simplify the task of feature extraction; c) feature extraction, in which the fingerprint is further processed to generate discriminative properties, also called feature vectors; and d) matching, in which the feature vector of the input fingerprint is compared against one or more existing templates. The templates of approved users of the biometric system, also called clients, are usually stored in a database. Clients can claim an identity and their fingerprints can be checked against stored fingerprints. The accuracy of a fingerprint matching algorithm is measured by:

- (i) FAR: It stands for false acceptance rate. It is defined as the ratio of the number of impostor images considered as authentic by the algorithm to the total number of impostor images.
- (ii) FRR: It stands for false rejection rate. It is defined as the ratio of the number of authentic images not considered qualified by the algorithm to the total number of authentic images.

When FAR and FRR are equal, we call it equal error rate (ERR). The performance of an algorithm is generally measured in terms of ERR.

IV. FINGERPRINT RECOGNITION APPROACHES

A. Minutiae Based Approach:

Finger prints are graphical ridge patterns present on human fingers, which due to their uniqueness and permanence, are among the most reliable human characteristics that can be used for people identification. A

common hypothesis is that certain features of the fingerprint ridges, called minutiae, are able to capture the invariant and discriminatory information present in the fingerprint image. 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). The representation of a fingerprint pattern thus comprises the attributes of all detected minutiae. By representing the minutiae set as a point pattern, the fingerprint verification problem can be reduced to a minutiae point pattern matching problem. Minutia-based extraction is one of the popular methods in fingerprint recognition. A reliable minutiae extraction algorithm is used to extract the landmark, such ridge bifurcations and ridge ends. The overall idea of minutia extraction mainly consists of three components, orientation field estimation, ridge extraction, and minutiae extraction and post processing. The minutiae based fingerprint recognition systems achieves very high accuracy. The shortcomings of this approach are:

- Images with artifacts such as compressed (or noisy) images can not be used with these recognition systems as they require high quality fingerprint images;
- Minutiae based systems are slow for real time applications;
- These systems have low recognition rates.

B. Pattern Recognition Approach:

A pattern is an arrangement of descriptors. It is characterized by the order of the elements of which it is made, rather than by the intrinsic nature of these elements. Pattern recognition is divided into two principle areas: Decision theoretic and Structural. Decision theoretic deals with patterns described using quantitative descriptors, such as length, area, and texture. Structural category deals with patterns best described by qualitative descriptors, such as the relational descriptors. A pattern class is a family of patterns that share some common properties. Pattern classes are denoted by $w_1, w_2, \dots, w_W$, where W is the number of classes. Pattern recognition by machine involves techniques for assigning patterns to their respective classes-automatically and with as little human intervention as possible. Three common pattern arrangements used in practice are vectors, strings and trees. Pattern vectors are represented in the following form:

$$X = [x_1, x_2, x_3, \dots, x_n] \quad (1)$$

Where each component, x_i represents the i th descriptor and n is the total number of such descriptors associated with the pattern. The nature of the components of a pattern vector x depends on the approach used to describe the physical itself. The key concept to keep in mind is that selecting the descriptors on which to base each component of a pattern vector has a profound influence on the eventual performance of object recognition based on the pattern vector approach. Finally fingerprint recognition is based on the interrelationships of print features called minutiae. Most of the Pattern recognition approaches uses texture feature of the images for classification. But the shortcoming of this approach is the analysis of image at one single scale.

C. Wavelet Based Approach

The steps involved in this approach are Fingerprint training and Fingerprint verification. In the fingerprint training, the known fingerprint images are decomposed using DWT. Then, the wavelet statistical features such as mean and standard deviation of approximation and 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 the formulas given in the Eqns. (1) and (2) respectively and stored in features library [13].

$$\text{Mean} = \frac{1}{N} \sum_{i,j=1}^N p(i,j)$$

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

where $p(i,j)$ is the transformed value in (i,j) for any sub-band of size $N \times N$. 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 [14]. The next step is fingerprint classification. Here, the fingerprint images, rotated by 0o to 360o in steps of 10o 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. Let

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

where $f_j(x)$ represents the features of unknown fingerprint while $f_j(i)$ represents the features of known i th fingerprint in the library. Then, the unknown fingerprint is verified as i th fingerprint, if the distance $D(i)$ is minimum among all fingerprints, available in the library. We take the finger print images of ten persons and there are two rotated images for every person. Hence the database consists of 30 images. We train the system using these 30 images and when an input image is given to the system, it should recognize the person if there is a match. We propose a combination of three texture descriptors namely Standard Deviation, Kurtosis and Skewness. DWT is the transform used for analysis. Canberra distance metric is used for similarity estimation [15]. A weakness shared by most of the texture analysis schemes is that the image is analyzed at one single-

scale; a limitation that can be lifted by employing a multi-scale representation of the textures such as the one offered by the wavelet transform [16].

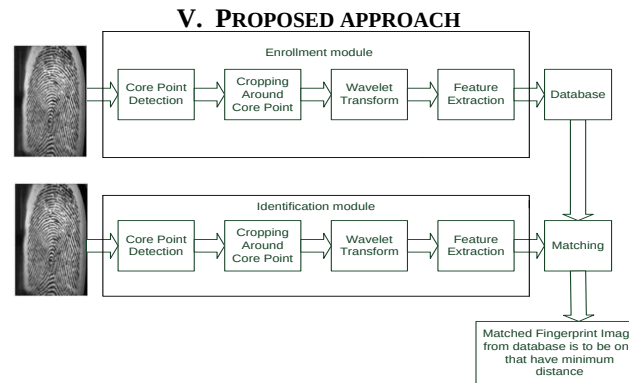


Fig. 3 Fingerprint Identification

Proposed Method Requires:

1. Core Point Detection
2. Image Cropping around Core point
3. Wavelet Transform
4. Feature Extraction (Wavelet signatures)
5. Feature Matching
6. Performance Evaluation

From above directive images Wavelet Signatures are calculated as feature set to store in database for the identification purpose. Texture can be characterized by the statistics of the wavelet detail coefficients and therefore introduces wavelet signatures as feature set.

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

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

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

Where $b(i, j)$, represents the pixel values of decomposed subimages, $N \times N$ is the size of decomposed subimage, M is the mean of subimage, S is the standard deviation of subimage and E is the energy of subimage. 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

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

Where F_i, F_t are feature vectors of database image and test image respectively. The performance of proposed algorithm has been measured in terms of genuine acceptance rate (GAR), False acceptance rate (FAR) and false rejection rate (FRR). Genuine acceptance rate = (True Claims accepted / Total true claims) × 100. False acceptance rate = (True Claims rejected / Total true claims) × 100. False rejection rate = (Imposter claim accepted / Total imposter claims) × 100.

VI. RESULT AND DISCUSSION

FVC 2002 Fingerprint data base is used. 20 fingerprints from 5 person is used. 4 impression were taken out from each person. 5 fingerprint image were used and processed and stored in data base. Result based on combined with wavelet energy signatures. The feature vector consist of wavelet energy signatures Standard deviations feature vector length = 36 standard deviations. Comparison of standard deviation of three different fingerprints.

Fingerprint	Standard Deviation				
1.	173.3044	204.1118	91.5501	25.0310	50.9854
	20.3184	6.9174	9.9582	2.8300	
2.	107.5783	240.6593	112.9954	32.1726	85.2771
	25.7758	5.6965	14.0704	2.9007	
3.	156.7727	224.2644	135.9373	31.2752	52.5570
	24.9429	6.0016	11.2797	2.6263	

TS (Training Set)= 1

In first testing, the input finger print image were same as the 5 fingerprint image were stored in data base.

Input fingerprint image from People no.	Database Fingerprint image	From people No.				Correctness
	1	2	3	4	5	100%
1.	M	0	0	0	0	100%
2.	0	M	0	0	0	100%
3.	0	0	M	0	0	100%
4.	0	0	0	M	0	100%
5.	0	0	0	0	M	100%
	Total %					100%

TS(Training Set) Training image =2

Input fingerprint image from People no.	Database Fingerprint image	From people No.				Correctness
	1	2	3	4	5	100%
1.	M	0	0	0	0	100%
2.	0	M	0	0	0	100%
3.	0	0	M	0	0	100%
4.	0	0	0	M	0	100%
5.	0	0	0	0	M	100%
	Total %					100%

In second testing 4 fingerprint impression from each person were loaded into the fingerprint identification system for verification. Total matching 95%.

Input fingerprint image from People no.	Database Fingerprint image	From people No.				Correctness
	1	2	3	4	5	
1.	4M	0	0	0	0	100%
2.	0	4M	0	0	0	100%
3.	1M	0	3M	0	0	75%
4.	0	0	0	4M	0	100%
5.	0	0	0	0	4M	100%
	Total %					95%

ACCURACY TABLE FOR DIFFERENT METHODS

TS(TRAINING SET)	TRADITIONAL DCT	TRADITIONAL FFT	FRIRV	WAVLET
TS=2	71.25%	73.75%	80%	95%
TS=1	95%	100%	100%	100%

VII. CHALLENGES WITH FINGERPRINT RECOGNITION

The main step in the system is to determine the core point location of fingerprint images.

The matching schemes assume that the reference point can be determined with a reasonable accuracy. The system may locate a wrong core point to the fingerprint image. Because of the core point was wrongly located, the image then cropped will not contained the same area with other cropped fingerprint impressions although the fingerprint impressions are all from the same person. As a result, this error will affect the identification process and matches the fingerprint wrongly. The low quality or distorted fingerprint image is perhaps the most common problem. The degradation can be of types like natural effects like cuts, bruises etc or it may be appearance of gaps on ridges or parallel ridge intercepts. The fingerprint enhancement techniques not only have to enhance the quality of image but also have to reduce noise. Much work has been done in this field and most commonly used method for this is application filters.

VIII. CONCLUSION

The research explored the use of wavelet transform to reduce the size of fingerprint images with less pre-processing the post-processing operations which made the system simple and less space and time consuming. It has also explored the combine use of Wavelet Energy Signatures and Wavelet Co-occurrence Signatures increases the recognition accuracy. The use of multi resolution, compactness and denoising property of wavelets makes it useful in fingerprint recognition system. The research needs some improvements in the future. By the use of other directional resolving algorithm of images the system performance can be increased. This system could have the better accuracy when the database images are trained using neural network, which has not been implemented here. The developed system has the satisfactory performance for the small test sample. The performance may be degraded when the sample size is increased. This can be addressed in future.

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