International Journal of Electronics Communication and Computer Engineering
Volume 4, Issue (2) ICEA-2013, ISSN 2249–071X

International Conference on Engineering Applications (ICEA)-2013

Fingerprint Recognition Using Multi-Resolution Techniques

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***Abstract* - Nowadays Biometric plays vital role in many applications. It is defined as the credentials of persons based on their physiological or behavioural characteristics. Biometric recognition can be classified into various types they are fingerprint, face, iris, palm print, voice, and DNA recognition. Among these fingerprint recognition plays major role since it do not change due to age factors, bruises cut, weather factor and so on. Multi-Resolution technique is used to enhance the recognition rate and reduce the time complexity by analysing finger image at diverse scale and different direction. In the existing system minutiae based technique has been used which is slower and has reduced recognition rate. In order to improve the recognition rate we move to the multi-resolution technique named Curvelet Transform. Curvelet is an extension of wavelet transform which is suitable for extracting ridge information from high frequency sub-band where as wavelet can be processed only at low frequency sub-band and it ignores the ridge information at high frequency sub-bands. The fingerprint feature is calculated based on the ridge information there by using Curvelet automatically increase the recognition rate up to 96%. The experiments were conducted using FVC 2000, 2002 and 2004 databases.**

***Keywords* - Pattern Recognition, Fingerprint Recognition, Curvelet Transform.**

I. INTRODUCTION

Biometrics is the unique pattern recognition of individuals based on the physiological and behavioural description. The physiological characteristics are face, fingerprint, DNA, palm print and iris that differs from person to person. The Behavioural characteristics are gaits, typing rhythm, speech were the behaviour that differs from individual to individual. Biometrics has been used in many applications like secure access in ATM, credit cards, Banking system, mobile phones, Laptops, etc,. It was introduced mainly to overcome the fraudulent access of secure information through what they hold like ATM, credit cards. Hence it is introduced to delineate "who they are" rather than "what they acquire" [1] [2].

Among the various biometric techniques we have choose fingerprint recognition technique. Since it does not change due to climatic condition and other real time challenges, whereas other characteristics like face, iris often gets changed under different lighting condition and aging factor.

Fingerprints are the frequent patterns created by ridge ending called termination and bifurcation pattern. These patterns are used for feature extraction in fingerprints. Since they fluctuate from one individual to other individual. Fig 1 shows the fingerprint pattern.

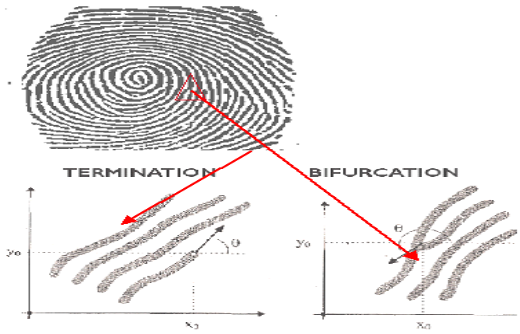


Fig.1. Fingerprint Pattern

Fingerprint recognition can be done by two approaches (i) Minutiae based approach: In which the points at ridge end and bifurcation ends are stored as feature vector[3] [4] [6].Hence it need large memory space to store the extracted features (ii) Image based approach: In which the entire image is utilized for generating feature vector using filters[7] [8]. Here the feature vector will be the statistical values like mean, standard deviation, etc,. Hence it needs less storage space to store the extracted features compared to minutiae based approach. Our proposed method is image based approach.

A. Motivation and justification of the proposed approach

Fingerprint can be viewed as a discontinuous sequence of ridge and bifurcation pattern. The points obtained at ridge and bifurcation ends are called Minutiae. In 19th centaury feature vector or finger code are calculated from these points. But it need large amount of storage space to store the feature. Also it does not support low quality fingerprint images like compressed images. It produce poor recognition rate when the dataset used is of poor quality. Also processing speed is very low. This drawback motivated us to make use of multi-resolution concept for generating finger code. The proposed method produce superior recognition rate with less storage space.

In 1999, Maio and Maltoni proposed minutiae based approach for extracting finger code. In which the system requires large amount of memory to store the extracted features. The recognition rate obtained was 86% [9]. Later many papers were proposed based on minutiae based approach from 2000 [10] [13]. In 2004 M.Poulos projected minutiae based extraction using Computational Geometry Algorithm (CGA) in which the memory spaces get reduced by storing only the required minutiae layer [14]. In 2006, Avinash Hnhalli anticipated feature extraction technique using Principal component of Analysis(PCA) in order to trim down the computation time during matching and to boost the recognition rate up to 90% [16][17][18]. In 1995 Wavelet has been re-evaluate by Amara Graps [19].

Later in 2010 wavelet (multi-resolution technique) has been used for fingerprint recognition to sustain low quality fingerprints [20] [21]. Whereas minutiae based approach need high quality fingerprints. Many other techniques for fingerprint recognition are stated in [22]. In Wavelet based technique lot of ridge information get lost due to the violation of processing high frequency sub-bands. This is shown in Fig.2. In Curvelet the ridge information were utilized efficiently by taking into account of high frequency sub-bands. Hence the recognition rate automatically gets increased up to 96%. So far, the Curvelet transform has been used for denoising, Content based image retrieval, etc,. Our paper is the first paper to use Curvelet transform for fingerprint recognition.

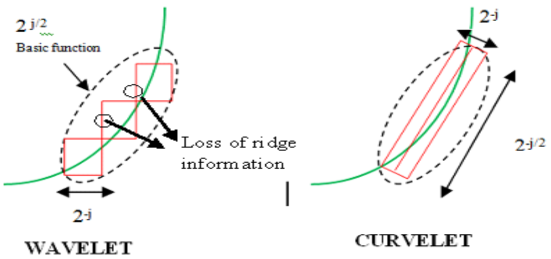


Fig.2. Continuities of curve in Wavelet and Curvelet

B. Outline of Proposed Approach

In this paper, one of the Multi-resolution techniques called Curvelet has been used to improve the recognition rate. Pre-processing technique is used to resize the fingerprint image to 128*128. During the training phase, the mean value of the sub-band decomposition at each level is used as the feature vector (finger code) for the given images. Then the extracted feature is stored in the database.

During the testing phase, the query image feature is compared with the features in the database using k-Nearest Neighbour classifier. The recognition system is shown in the Fig.3.

C. Organisation of the paper

The association of the paper are as follows. Section 2 illustrates overview of Curvelet transform. Section 3 portrays feature extraction using Curvelet in detail. Section 4 describes the classification principle. Section 5 reveals experiment conducted using FVC 2004 dataset. Section 6 represents the conclusion and future enhancement of the work.

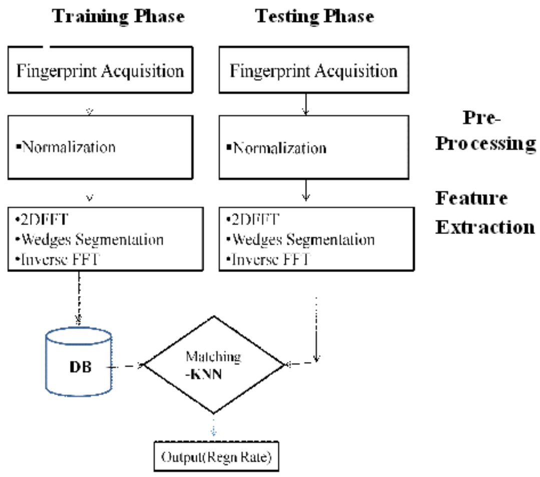


Fig.3.System Architecture

II. Overview of Curvelet Transforms

Curvelet transform was developed by candes et al. [24] [25]. It is an extension of wavelet transform with multi-scale and fine directional resolution property. In wavelet transform the directional feature can be extracted only in three directions namely horizontal, vertical and diagonal direction whereas Curvelet transform captures all directions along wedges formed using Curvelet decomposition. There are two generation of Curvelet transform namely first and second generation. The first generation Curvelet transform is an extension of Ridgelet transform [26] [27]. Ridgelet is a time consuming process and it is less feasible for texture analysis. So the second generation Curvelet transform was proposed by candes et al using Fourier samples that is, unequally-spaced fast Fourier transform (USFFT) and wrapping based fast Curvelet transform. Wrapping based Curvelet transform is quicker in computation time and more vigorous than Ridgelet and USFFT based Curvelet transform [28]. In this paper we are using wrapping based Curvelet transform. Complete concept of Curvelet can be learned from [29] [30].

III. Feature Extraction Using Curvelet

Most of the images are represented as a collection of lines like curves, edges. On using wavelet transform for feature extraction of images shrink recognition rate. Usually finger images are completely made of curves (ridges/bifurcation). If wavelet is used for feature extraction the edge information is lost completely. Since it decompose only the low frequency sub-bands. Hence recognition rate get reduced. So on using Curvelet which takes ridge information present at high frequency sub-bans into account. There by edge information is utilized efficiently and hence recognition rate is improved automatically. The feature extracted as follows, the fingerprint image as considered as an array f [m, n] such that 0≤m<M and 0≤n<N. Then Curvelet co-efficient C^D is generated using the equation 1

$$C^D(j,l,k1,k2) = \sum_{\substack{0\le m<M \\ 0\le n<N}} f[m,n]\phi^D_{j,l,k1,k2}[m,n] \quad \ldots\ (1)$$

Where j represents scaling factor l represents orientation, (k1, k2) are two spatial location and $\phi^D_{j,l,k1,k2}[m,n]$ represents digital Curvelet waveform. The superscript D represents Digital format. In the frequency domain, Curvelet is indicated as a product of two windows such as radial window and angular window called Digital Curvelet Transform that bears concentric squares. The product of these two windows separate frequencies near the wedge $2^j \le \infty_1 \le 2^{j+1}$, $-2^{-j/2} \le \infty_2 \le 2^{j/2}$ are represented in equation 2.

$$U_{j,l}(\infty) = W_j(\infty)V_j(\infty) \quad \ldots\ldots\ldots\ldots.2$$

Where $V_j(\omega)$ is the real valued, smooth angular window, $W_j(\omega)$ is the radial window used to separate the scales of the frequency plane defined in equation 3.

$$W_j(\infty) = \sqrt{\varphi^2_{j+1}(\infty) - \varphi^2_j(\infty)} \quad \ldots\ldots\ldots.3$$

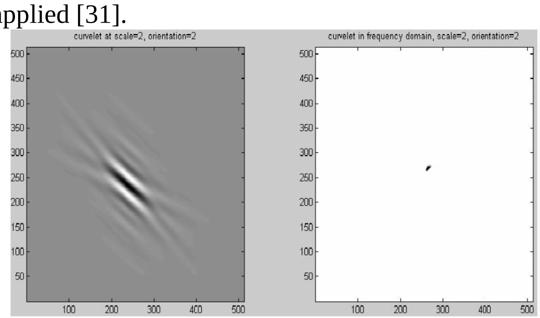
Where φ is equal to 1 in [-1/2,1/2] and disappears outside [-2,2] and it is described as the product of one dimensional low pass window and it is given by equation 4.

$$\varphi_j(\infty_1,\infty_2) = \varphi(2^{-j}\infty_1)\varphi(2^{-j}\infty_2) \quad \ldots\ldots.4$$

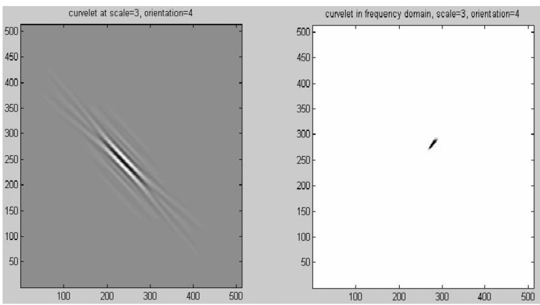
The Curvelet coefficient at frequency domain is given by [30]

Curvelet Coefficient=IFFT [FFT(Curvelet)*FFT (Image)].

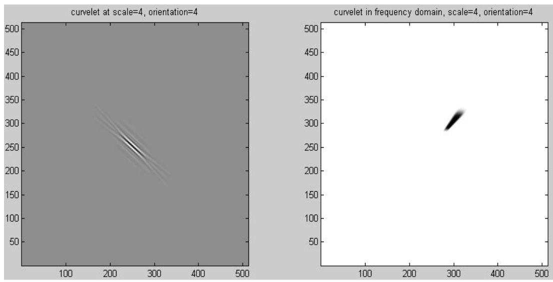
Where IFFT is the Inverse Fast Fourier Transform and FFT is the Fast Fourier Transform. The digital Curvelet transform obtained so is not in rectangular form. So to make it into rectangular form wrapping technique has to be applied [31].



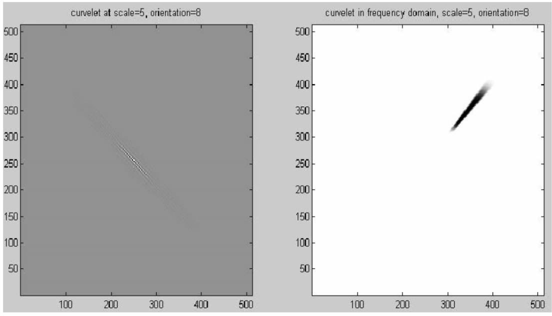
(a) curvelet at scale=2, orientation=2



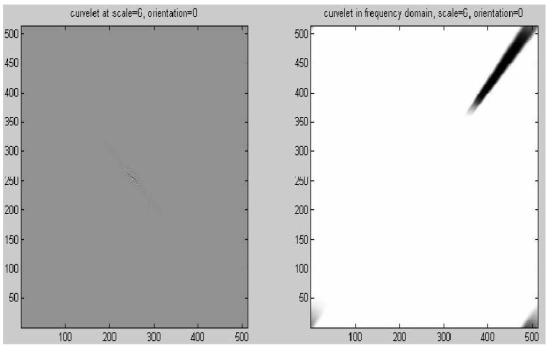
(b) curvelet at scale=3, orientation=4



(c) curvelet at scale=4, orientation=4



(d) curvelet at scale=5, orientation=8



(e) curvelet at scale=6, orientation=8

Fig.4. Curvelet (absolute value) at different scales at a single direction are shown in the spatial domain (left) and in the frequency domain (right).

A. Wrapping Technique

Fig.4 shows the wrapping technique in Curvelet at different orientation (2, 4, 8) with each scale (1-6). This is obtained using curve lab 2.1.2 [36]. By merging frequency response of Curvelet at altered scale and orientation, Curvelet rectangular frequency tiling (Fig .5) is attained. From the figure it is clear that the Curvelet is sensitive to orientation on ever-increasing the scale. The steps to obtain wrapping based Curvelet are as follows (i) Take the FFT of the given image. (ii) Determine the product of Fourier sample of digital Curvelet transform and given the image. (iii) Wrap the product around the centre to determine the rectangular form (Fig.6). (iv) Take IFFT of the wrapped product this act as Curvelet coefficient which is arranged in ascending order of scales and orientation. Fig.7 shows complete feature extraction using Curvelet.

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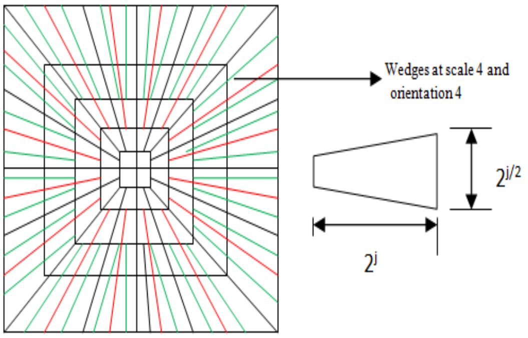


Fig.5. Curvelet Frequency Tiling

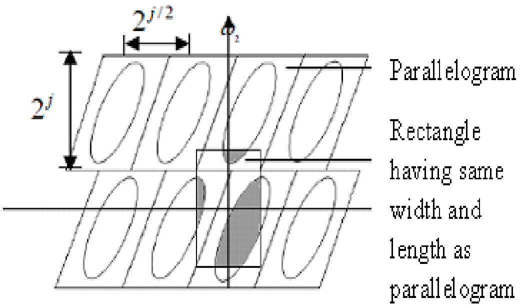
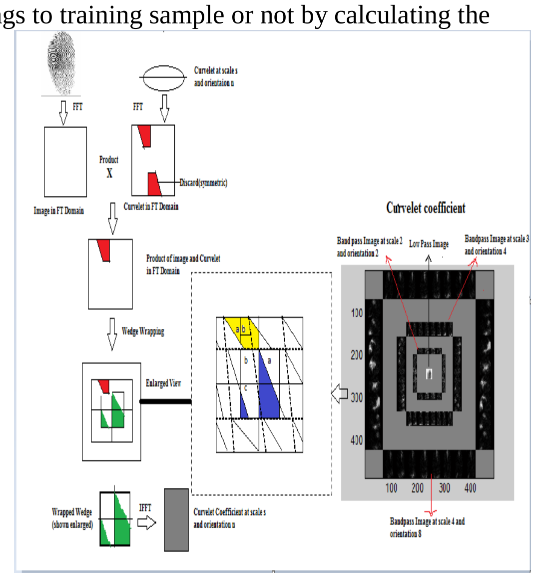


Fig.6. Wrapping method. The support in a parallelogram is finally into a rectangle.

The mean value of the Curvelet at each level is taken as a feature vector. This is stored in the database.

IV. Classifications

Classification is the process of comparing the Feature generated for the query image given in the testing phase with stored feature in the database that are extracted during training phase. This can be done with the help of Fuzzy K-Nearest Neighbour classifier. The K-Nearest neighbour (K-NN) classifier just defines whether a sample belongs to training sample or not by calculating the



Euclidian distance between the test sample and all the images in the training sample[32][33]. The sample that has minimum distance in the database is returned as a matched sample, but the relationships with other sample in the database were ignored. So Fuzzy K-NN is used, which not only define the matched sample, but also define how close the sample is related with other samples in the database [34].

V. Experiments and Result Discussion

A. Database and results

Our experiments were conducted using Fingerprint Verification Competition (FVC) 2004 Database [35] DB1. The sample dataset from FVC 2000, 2002 and 2004 consist of 880 fingerprint images of 110 individuals with 8 fingerprints to each individual. Fig.8 shows the experimental setup. In our experiment we choose 80 fingerprint images of 10 individuals randomly from all three datasets. In the training set we chose 3 images of an individual randomly and in the testing set remaining 5 images were kept for comparison. So totally 30 images were used for training and 50 images were used for testing.

Table 1 demonstrate the recognition rate of minutiae, wavelet and Curvelet based technique using three different datasets like FVC 2000, 2002 and 2004. In FVC 2000 the fingerprint images were obtained using low cost "Secure Desktop Scanner" optical sensor and in FVC 2002 the images were acquired using "TouchView II" optical sensor. The fingerprints in FVC 2004 database were obtained using V300 optical sensor. During acquisition, the sensor plates were not cleaned so as to fight with the challenges faced by real life situation. In FVC 2000 and 2002 Database, the fingerprint images obtained are of high quality than FVC 2004, also the ridge information are more prominent than FVC 2004. Hence they produce high recognition rate when compared to FVC 2004.

Table 2 shows the recognition rate of partially obtained images. This experiment was conducted using FVC 2002 and 2004. The recognition rate obtained so is similar in both dataset with 20 images in training and 10 images in testing. But the time taken to process the image get differs. This is due to the difference in quality of images in dataset.

The high quality dataset FVC 2002 need less time when compared with low quality dataset FVC2004.

Table 3 illustrate the recognition rate of fingerprint images under noisy condition. Here the experiments were accomplished using two datasets namely FVC 2002 and 2004 with 30 images in training and 20 images in testing. The recognition rate obtained is higher than the recognition rate obtained in Table 2. This is because the fingerprints used here is chock-full with noise whereas in experiment 2 only partial fingerprints were used not the complete image.

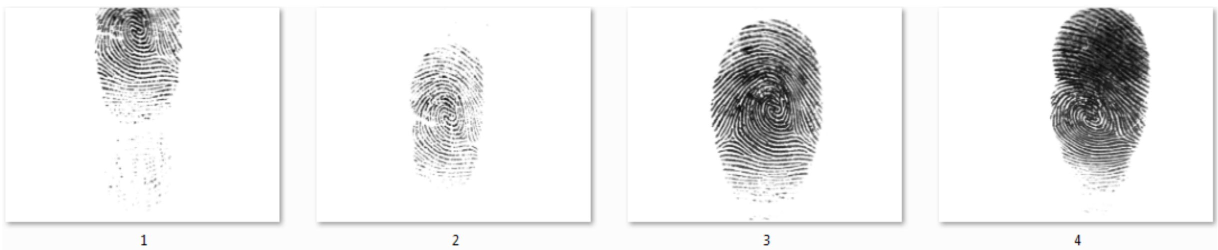
Table 4 make obvious about the recognition rate obtained at different rotation angle like 45°, 90°, 135°. From the table it is clear that as the rotation angle increases the recognition rate decreases and the time taken to compute the feature increases tremendously.

Thus from the above experiments it is clear that using Curvelet transform for fingerprint recognition produce recognition rate up to 96% under normal condition, 90 % under partial condition and 95 % under noisy condition. Hence it produces better result when compared with other two techniques like Wavelet and minutiae based method by utilizing the ridge nformation efficiently than wavelet. Also it requires less memory space to store extracted features when compared with minutiae based technique.

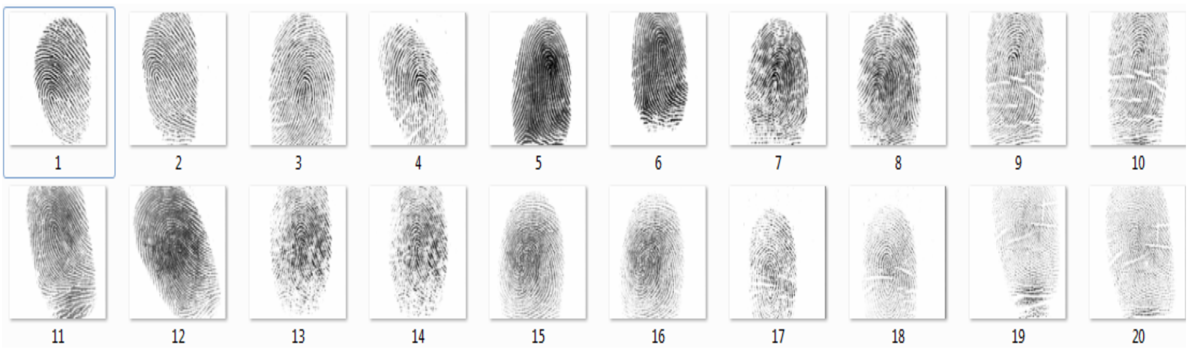
Experimental set up

(a)

(b)



(c)



(d)

(e) *(f)*

Fig. 8.(a) Samples from FVC 2000 (b) Samples from FVC 2002 (c) Samples from FVC 2004 (d) Training Samples from FVC 2004 (e)Testing Samples from FVC 2004 under partial condition (f) Testing Samples from FVC 2004 under noisy condition.

5.3 Results

Table 1 Recognition rate of three technique using three Datasets

Algorithm	Recognition Rate			Average Recognition Rate
	FVC 2000	FVC 2002	FVC 2004	
Minutiae Method	86.77	89	83.67	86.48
Wavelet	91	93.32	90.17	91.49
Curvelet	96.67	98	93.33	96

Table 2: Recognition rate of two techniques using two Datasets under partially obtained images

Database used	Curvelet		Wavelet	
	Recognition rate %	Time taken(ms)	Recognition rate %	Time taken(ms)
FVC 2002	90.33	0.4785	85.23	0.4132
FVC 2004	90	0.5402	86.13	0.4792
Average	90.165	0.50935	85.68	0.4462

Table 3: Recognition rate of two techniques using two Datasets under noisy condition

Database used	Curvelet		Wavelet	
	Recognition rate %	Time taken(ms)	Recognition rate %	Time taken(ms)
FVC 2002	95	0.6111	91.43	0.5412
FVC 2004	95	0.6123	90	0.5781
Average	95	0.6117	90.72	0.5597

Table 4: Recognition rate of two techniques using two Datasets under different rotation angle

Rotation Angle	Curvelet using FVC 2004	
	Time Taken (ms)	Recognition rate %
45°	0.4701	95
90°	0.6128	90
135°	0.9447	80

VI. Conclusion and Future Enhancement

Fingerprint recognition based on Curvelet transform produce better recognition rate compared to wavelet and minutiae based technique. The recognition rate obtained using minutiae based method was 86%, whereas wavelet produce recognition rate up to 91% and the proposed multi-resolution technique produce higher recognition rate of 96%. Also the time taken to extract the feature is less in Curvelet when compared with wavelet and minutiae based method. Also space required to store the extracted feature is less in proposed method when compared to minutiae based method.

The direction resolution property of Curvelet is less when compared to Contourlet transform. So using Contourlet produce even higher recognition rate than

Curvelet since it has fine direction resolution property than Curvelet. Also multi-biometrics like fusion of finger with face and iris recognition system can be used to provide higher security.

References

[1] S. Prabhakar, S. Pankanti, A. K. Jain, "Biometric Recognition: Security and Privacy Concerns", *IEEE Security & Privacy*, March/April 2003, pp. 33-42

[2] A. K. Jain, A. Ross, S. Prabhakar, "An Introduction to Biometric Recognition", *IEEE Trans. on Circuits and Systems for Video Technology*, Vol. 14, No. 1, pp 4-19, January 2004.

[3] A. K. Jain, A. Ross and S. Pankanti, Fingerprint matching using minutiae and texture features, *Proc. International Conference on Image Processing ICIP, Thessalonica, GR*, 281-285 (2001).

[4] D. Maio, D. Maltoni, Direct gray-scale minutiae detection in fingerprints, *IEEE Transactions on PAMI* 19(1), 27-40 (1997).

[5] Anil Jain, Sharath Pankanti, "Fingerprint Classification and Matching", Department of CSE,Michigan State University.

[6] A. K. Jain, L. Hong, and R. Bolle, "On-line fingerprint verification," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 19, no. 4, pp. 302–314, Apr. 1997

[7] Andrew Teoh Beng Jin*, David Ngo Chek Ling, Ong Thian Song "An efficient fingerprint verification system using integrated wavelet and Fourier–Mellin invariant transform", Image and Vision Computing 22 (2004) 503–513,Elsevier.

[8] Sadegh Helfroush and Hassan Ghassemian, "Nonminutiae-Based Decision-Level Fusion for Fingerprint Verification", Hindawi Publishing Corporation EURASIP Journal on Advances in Signal Processing Volume 2007, Article ID 60590, 11 pages doi:10.1155/2007/60590.

[9] D. Maio and D. Maltoni. Minutiae Extraction and Filtering from Gray-Scale Images. In L.C. Jain et al., editor, *Intelligent Biometric Techniques in Fingerprint and Face Recognition*, pages 155–192. CRC Press LLC, 1999.

[10] S. Prabhakar, A.K. Jain, J. Wang, S. Pankanti, and R. Bolle. Minutia Verification and Classification for Fingerprint Matching. In *Proc. ICPR2000, 15th Int. Conf. Pattern Recognition*, Barcelona, Spain, September 2000.

[11] A.K. Jain, S. Prabhakar, L. Hong, and S. Pankanti. Filterbank-Based Fingerprint Matching. *IEEE Trans. Image Processing*, 9(5):846–859, May 2000

[12] A. K. Jain, S. Prabhakar, and L. Hong. A Multichannel Approach to Fingerprint Classification. *IEEE Trans. PAMI*, 21(4):348–359, April 1999.

[13] A. K. Jain, A. Ross and S. Pankanti, Fingerprint matching using minutiae and texture features, *Proc. International Conference on Image Processing ICIP,Thessalonica, GR*, 281-285 (2001).

[14] M. Poulos et al final," Fingerprint Verification Based On Image Processing Segmentation Using An Onion Algorithm Of Computational Geometry", February 21, 2004 , WSPC.

[15] Ramesha K and K B Raja, "Face Recognition System using Discrete Wavelet Transform and Fast PCA," *Proceedings of the International Conference on Advances in Information Technology and Mobile Communication*, pp. 13-18, 2011.

[16] Avinash Hnhalli Ramalingegowda, "Fingerprint Recognition Using Wavelets and Principal Component Analysis",Texas A&M University - Kingsville, 2006

[17] Wang Yongxu , "A Fingerprint Recognition Algorithm Based on Principal Component Analysis", TENCON 2006. 2006 IEEE Region 10 Conference.

[18] Asker M. Bazen Fingerprint Identification - Feature Extraction, Matching, and Database Search Final version: August 19, 2002

[19] Amara Graps *1995* "An Introduction to Wavelets" *The original version of this work appears in IEEE Computational Science and Engineering, Summer 1995,vol. 2, num. 2, published by the IEEE Computer Society, 10662 Los Vaqueros Circle, Los Alamitos, CA 90720, USA,TEL +1-714-821-8380, FAX +1-714-821-4010.*

[20] Rakesh Verma, Anuj Goel, "Wavelet Application in Fingerprint Recognition" International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-4, September 2011

[21] Avinash Pokhriyal, Sushma Lehri ,"A New Method Of Fingerprint Authentication Using 2d Wavelets", Journal of Theoretical and Applied Information Technology, 131 Vol. 13 No.2 March, 2010 pp (131 - 138) © 2005 - 2010 JATIT.

[22] "A Handbook Of Fingerprint Recognition", Maltino, Maio, Jain And Prabhakar. Springer Press.

[23] "Digital Image Processing", Gonzalez And Woods, PHI, 2002

[24] E. Candès and D. Donoho, "Continuous curvelet transform. I. Resolution of the wavefront set," *Appl. Comput. Harmon. Anal.*, vol. 19, no. 2, pp. 162–197, 2005.

[25] E. Candès and D. Donoho, "Continuous curvelet transform. II. Discretization and frames," *Appl. Comput. Harmon. Anal.*, vol. 19, no. 2, pp. 198–222, 2005.

[26] J.-L. Starck, E. J. Candès, and D. L. Donoho, "The Curvelet Transform for Image Denoising," *IEEE Transactions on Image Processing*, vol. 11(6), pp. 670-684, 2002.

[27] E. J. Candès and D. L. Donoho, "Ridgelets: a key to higher-dimensional intermittency?," *Philosophical Transactions of the Royal Society of London. A.*, vol.357, pp. 2495–2509, 1999.

[28] M. J. Fadili and J.-L. Starck, "Curvelets and Ridgelets," *Encyclopedia of Complexity and System Science , in press.*, 2007.

[29] Jianwei Ma and Gerlind Plonka, "The Curvelet Transform", *IEEE Signal Processing Magazine [118], 1053-5888/10 2010IEEE March 2010.*

[30] Ishrat Jahan Sumana, "*Image retrieval using discrete curvelet transform*", A master's thesis from Monash University, Australia, available http://personal.gscit.monash.edu.au/~dengs/resource/papers/Sumana_Thesis.pdf

[31] Emmanuel Cand`es, Laurent Demanet, David Donoho, and Lexing Ying, "Fast Discrete Curvelet Transforms", available at http://www.curvelet.org/papers/FDCT.pdf

[32] B. V. Dasarathy (Editor), "Nearest neighbor (NN) norms:NN pattern classification techniques", IEEE Computer Society Press, Los Alamitos, California, 1990.

[33] G. Shakhnarovish , T. Darrell and P. Indyk (Editor) "Nearest-Neighbor Methods in Learning and Vision", The MIT Press, 2005.

[34] J. M. Keller, M. R. Gray, and J. A. Givens, Jr., "A Fuzzy K-Nearest Neighbor Algorithm", IEEE Transactions on Systems, Man, and Cybernetics, Vol. 15 (4), pp. 580-585, 1985.

[35] http://bias.csr.unibo.it/fvc2004/databases.asp

[36] http://www.curvelet.org/software.html.