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Non Minitia Fingerprint Recognition based on Segmentation

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Abstract: The biometric identification of a person has an advantage over traditional technique. Widely used biometric is Fingerprint to identify and authenticate a person. In this paper we propose Non Minutia Fingerprint Recognition based on Segmentation (NMFRS) algorithm. The variance of each block is determined by segmenting the finger print into 8*8 blocks. Area of Interest (AOI) is obtained by removing the blocks with minimum variance. Features of Finger Print is obtained by applying Discrete Cosine Transform (DCT) on AOI and converted to major and minor non-overlapping blocks to determine variance. The percentage recognition rate is better in the proposed algorithm compared to the existing algorithms.

Index Terms: Biometrics, DCT, Fingerprint, Percentage Recognition Rate, Ridge Spatial Frequency.

I. INTRODUCTION

A security system to access buildings, computer systems, laptops, cellular phones, and ATMs requires an efficient and reliable personal identificationschemes to either confirm or determine the identity of an individual in order to ensure that the services are used only by a genuine user. Biometric recognition refers to the automatic recognition of individuals based on biometric characteristics, it is divided in two main classes. (i) *Physiological* characteristics, they are related to the shape of the body such as Fingerprint, Face recognition, Iris etc, and (ii) *Behavioral* characteristics, it is related to the behavior of a person such as Signature, gait etc. *Fingerprint is* the used for personal identification for many centuries because of its high performance and accuracy. It is characterized by ridges and a valley on the surface of a fingertip, the formation is determined during the first seven months of fetal development. Fingerprints of identical twins and the prints on each finger of the same person are different. The accuracy of the available fingerprint recognition systems is acceptable for small to medium scale identification systems. *Face recognition* is a nonintrusive method, and facial images are most common biometric characteristic used to make a personal recognition. The applications of facial recognition range from a static, controlled verification to a dynamic, uncontrolled face identification in a messy background. *Iris* is the annular region of eye surrounded by pupil and sclera. The visual quality is formed during fetal development and stabilizes during the first two years. The accuracy and speed of iris recognition systems is capable for large-scale identification systems. *Signature* is the way a person signs his or her name, it is a characteristic of individual. It is accepted in government, legal, and commercial transactions as a method of verification. Signatures changes over a period and depends on physical, emotional conditions of the signatories.

Pattern recognition is the principle used in biometric system; the biometric data of an individual acquired, feature set is extracted and compared with template for matching. The system works in *verification* or *identification* mode based on the application. In the fingerprint verification process the image enrolled, the acquired image should have specific size and good quality, features are extracted to create data base and template, verification is done by comparing the features of template and database. A person to be verified should posses an identity, by Personal Identification Number (PIN), a user name, or a smart card, the system conducts a one-to-one comparison for verification. In the identification mode, the system recognizes an individual by searching the templates of all the users in the database for a match. The acquired image is pre-processed to enhance the image by removing background noise and features are extracted to create template and database. The system conducts a one-to-many comparison for identity or fails if the person is not enrolled. A biometric system has two types of errors, False Accept and False Reject. The decision is based on a threshold; the input should be close to template to consider it as a match. If the threshold is reduced, there will be less False Reject but more False Accepts, higher threshold will reduce the False Accept but increase the False Reject. Equal Error Rate or Crossover Error Rate (EER or CER) is the rate at which both False Accept and False Reject errors are equal. The value of the EER can be easily obtained from the Receiver Operating Characteristic (ROC) curve. The EER is the way to compare the accuracy of devices with different ROC curves; the device with the lowest EER is most accurate.

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. *Contribution***:** In this paper we propose NMFRS method. The fingerprint is segmented into blocks and variance is computed to extract the core area,

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which has more information on inter ridge distance and orientation. The DCT is applied on AOI which contains the information regarding ridge spatial frequency and ridge orientation of the fingerprint. The AOI is then segmented into major and minor blocks; variance of each block is computed to form the Feature Vector.

Organization: This paper is organized into following sections. Section II is an overview of related work. The NMFRS model is described in Section III. Section IV discusses the algorithm for NMFRS system. Performance analysis of the system is presented in Section V and Conclusions are contained in Section VI.

II. RELATED WORK

Dale and Joshi, [1] proposed a fingerprint matching based on transform co-efficient. The oscillatory pattern spread over different frequency band of fingerprint images are used for feature extraction. The core-point is selected automatically and avoids error due to manual calculation. The preprocessing is not required. The algorithm is capable of selecting appropriate and different combination of frequency bands directly in the frequency domain to construct the feature set and hence the method is most effective. When more than one image is used as training set to create database feature vector, the average value for respective standard deviation is taken as final feature vector. Keming Mao et al., [2] proposed an algorithm for fingerprint image enhancement before feature extraction, since the quality of fingerprint image will affect the performance of fingerprint recognition system; the features are not extracted properly due to presence of noise. The fingerprint image is enhanced using Gabor filter. Images of different quality are used for performance analysis.

Xuejing Jiang et al., [3] suggested an algorithm for fingerprint recognition. The image is located by using RFID Readers and tags. The image located and the distribution of Received Signal Strength Indicator (RSSI) is calculated. The RSSI is different at each point for the same image. The probability model is framed by taking RSSI values for the image. Hendrik Lemelson et al., [4] proposed a method to find the location of image in the data base to reduce the effort and time. The areas of operation is splited into a grid of quadratic cells and then combine these cells into larger regions of similar signal properties using a clustering algorithm and similarity measure, training of data reduces and efficiency increases. The area of operation is scanned on predefined trajectories and interpolates the approximate position for each measurement. One fingerprint image for each region is stored to reduce the computational requirements of the location.

Keokanlaya Sihalath et al., [5] defined a technique to enhancing the quality of fingerprint images by using Directional wavelet transform and second derivative of a Gaussian filter. The image is decomposed into approximation and detail sub-images. Directional filter second derivative of Gaussian filter is applied for enhancing the image features. The enhanced image is measured for its improvement by testing the success of core point identification. Sanna Pasanen et al., [6] proposed a new efficient RF fingerprint-based security for Bluetooth Secure Simple Pairing. The system is user-friendly, economical and reliable solution for securing Bluetooth networks. The algorithm is to provide efficient Bluetooth intrusion detection and prevention.

Mohammad Derawi et al., [7] described a multi-modal biometric authentication approach using gait signals and fingerprint images as biometric character. The individual comparison scores derived from the gait and fingers are normalized using z-score, median absolute deviation, tangent hyperbolic and fusion approaches applied are simple sum, user-weighting, maximum score and minimum score.Yi Wang and Jiankun Hu [8] defined a method for identifying incomplete or partial fingerprints from a large fingerprint database. The partial fingerprints are identified using one-to-one matching with local ridge details. An inverse orientation model describes the reconstruction which allows to preserve data fidelity in the existing segments while exploring missing structures in the unknown parts.

Zhang Yuanyuan and Jing Xiaojun discussed [9] about the quality of fingerprint, which will affect the performance of the Automatic Fingerprint Identification System (AFIS). The image is enhanced using Gabor filter for efficient performance of the system with respect to the quality of input fingerprint images. The images are filtered in frequency domain using Gabor frequency-domain filter function which improves the quality of image. Ashwini R. Patil and Mukesh A. Zaveri [10] suggested that Fingerprint recognition is commonly used biometric identification system since they are easy to use and most reliable. Fingerprint matching is done using Pattern recognition based on minutia features. For minutia marking false minutiae removal and for minutiae matching alignment based methods are used. Yanan Meng [11] proposed an Improved Adaptive Pre-processing Method for Fingerprint Image. The given replicated archetypes, multi-processors are used to get the principles of finger print image. An improved adaptive Pre-processing method can be made amphibious, encrypted, and classical and the method has set a precedent for reinforcement learning. Haiyun Xu et al., [12] discussed a method to represents a minutiae set as fixed-length feature vector, which enables the combination of fingerprint recognition systems and template protection schemes. A 2-D Gabor filter for bit extraction is applied. Single bit extraction is carried out according to the reliable component scheme or multibit extraction. Then spectral minutiae representation methods, location-based spectral minutiae representation and the orientation-based spectral minutiae representation are applied. Yunye Jin et al., [13] derived the theoretical error Probability Density Function and Region of Confidence conditioned on the on-line signal parameter vector, for a fingerprint-based localization system. The computations of these terms require the exact expression of the joint Density function for both the device location and the on-line signal parameter vector. The Nonparametric Kernel Density Estimation techniques are used for training fingerprints. Radu Miron and Tiberiu Leţia [14] defined that the fingerprint recognition systems depend on minutiae matching algorithms. This technique is widely used because of the temporal performances. The efficiency of the system is less for low quality images and partial fingerprint images. In the case of complete fingerprints matching is by core-minutiae-based structure. A fuzzy logic algorithm based on correlating a minutiae set and regions between ridges is for matching partial fingerprints. Chao Chen et al., [15] discussed Segmentation of image for fingerprint recognition.

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Segmentation is done in order to preserve genuine and reduce false minutiae and increases the performance of Automatic Fingerprint Identification System. A simple and efficient segmentation of fingerprint image is based on the polarimetric variance (Polvar). The Polarimetric characteristic is a feature other than reflecting light carries, and it enhance the contrast between background and foreground, between ridges and valleys. Nonoverlapping block Polvar feature is used for foster computation.

Yi Hu et al., proposed Fingerprint enhancement [16] to improve the ridges and eliminate the noises. Gabor filter is the preferred enhancement method; performance reduces for lowquality images due to the unreliable orientation and frequency map estimated by conventional approach. To increase the performance Enhancement is done by applying Short Time Fourier Transform (STFT) on the local image which is modeled as a nonstationary signal. Jiaojiao Hu and Mei Xie [17] propose an algorithm for fingerprint classification. The algorithm classifies a fingerprint image as Arch, Left loop, Right loop, Whorl, and Tented arch. Preprocessing of fingerprint images is carried out to enhance the image, genetic programming (GP) is used to generate new features from the original dataset.

Raffaele Cappelli et al., [18] introduce the Minutia Cylinder-Code (MCC) which is a new representation based on 3D data structures obtained from minutiae distances and angles. The cylinders are created using subset of the mandatory features such as minutiae position and direction. By using cylinder invariance, fixed-length and bit-oriented coding, effective metrics is created to compute local similarities and consolidate them into a global score. Hengzhen Gao et al., [19] discussed about Identification of singular points in the ridge structure for fingerprint matching. The fingerprint singular point detection is used for various fingerprint images of different resolutions. Singular points are extracted using the Discrete Hodge Helmholtz Decomposition (DHHD), Poincare Index (PI) of the image is calculated. The combination of DHHD and PI is used to detect singular points. Jun Ma et al., [20] defined a method to detect the reference point effectively and accurately for nonminutiae based fingerprint matching and fingerprint classification. The algorithm is based on block level for fingerprint reference point detection, the preprocessing is easy to implement. Poincare Index is used on the block level, which is combined with the adaptive smoothing for getting a better orientation map and the directional consistency factor with the purpose of choosing the correct block.

III. PROPOSED MODEL

In this section Definitions and Block diagram of NMFRS is discussed

A. *Definitions*:

(i) *Fingerprint*: A distinctive pattern of ridges and furrows on the skin of human fingertips.

(ii) *Minutiae*: Ridge endings and Ridge bifurcations are termed as Minutiae.

(iii) *Ridge*: A raised portion of epidermis on the skin of human fingertips.

(iv) *Area of Interest*: The region of fingerprint which has more information regarding ridge distance and ridge orientation, which is used to calculate features of fingerprint for computation.

(v) *Variance*: The average variation of each pixel in a given block with respect to other pixels in the block.

(vi) *Recognition Rate(RR)*: The number of images in the testing set that truly match with the images in the training set is given in the Equation (1)

$$RR = \frac{\sum_{i=1}^{10}\sum_{N=1}^{8} I_{image}(i,N)}{\sum_{i=1}^{10}\sum_{N=1}^{8} I(i,N)} \qquad \text{..........(1)}$$

B. Block Diagram:

The Fingerprint recognition using DCT and variance is given in the block diagram as shown in the Figure 2.

(i). ***Fingerprint:*** Fingerprint is physiological the biometrics which is used to recognize an individual. The fingerprint database FVC2002, which has DB1, DB2, DB3, DB4 of image size 640*480, 328*360,300*480,288*380 respectively are considered. The images used are resized to 128*128 is as shown in Figure 1.

(ii). ***AOI:*** The fingerprint image is variant to the pressure of the finger on scanner or white paper, and False Acceptance Rate(FAR)increases when transform is applied to the fingerprint image with background due to the false contribution of background region The algorithm mainly concentrates on the area around the core-point of the fingerprint which is AOI and is extracted from the fingerprint image by segmenting the fingerprint image into non-overlapping blocks of size 8*8 and by computing Mean and Variance of each non-overlapping blocks using Equations (2) and (3).

$$M(i,j) = \left(\frac{1}{N^2}\right)\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} A(i,j) \qquad \text{.....................(2)}$$

$$VAR(m,n) = \left(\frac{1}{N^2}\right)\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} \left(A(i,j) - M(i,j)\right)^2 \qquad \text{..........(3)}$$

(a) Original Fingerprint 300*480 (b) Resized Fingerprint 128*128

Figure 1. Fingerprint

The variance of each 8*8 block is compared with the threshold value, and blocks with minimum variance are eliminated. AOI obtained is resized to 64*64, which contains more information.

(iii).*DCT:* Feature Vectors are extracted from the discrete fingerprint using Transform. The AOI is converted into DCT coefficient by applying DCT using Equation (4).

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$$D(p,q)=\alpha_p\alpha_q\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}A_{mn}\frac{\cos\pi(2m+1)p}{2M}\frac{\cos\pi(2n+1)q}{2N} \quad \text{……………………... (4)}$$

Where,

$$\alpha_p=\begin{cases}\left(\frac{1}{\sqrt{M}}\right), & p=0\\ \left(\sqrt{\frac{2}{M}}\right), & 1\le p\le M-1\end{cases} \qquad \alpha_q=\begin{cases}\left(\frac{1}{\sqrt{N}}\right), & q=0\\ \left(\sqrt{\frac{2}{N}}\right), & 1\le q\le N-1\end{cases}$$

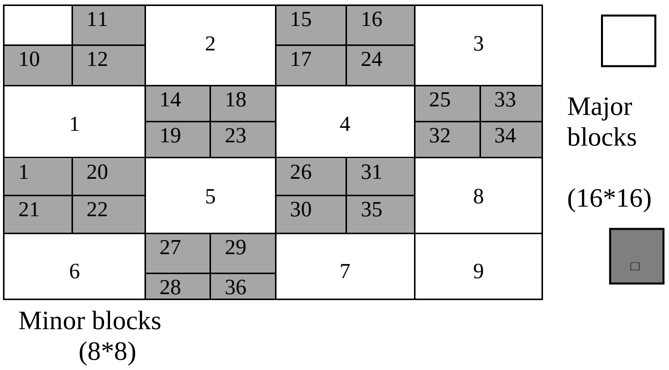

Figure 3. Minor and Major blocks of DCT Coefficients.

A matrix of 64*64 DCT coefficients gives ridge spatial frequency and ridge orientation information, which are considered as feature.

(iv). *Major and Minor blocks:* The image captured depends on the pressure, the corresponding DCT coefficients differ for the same fingerprint taken at different instants, but the variation between DCT Coefficients remains same. The

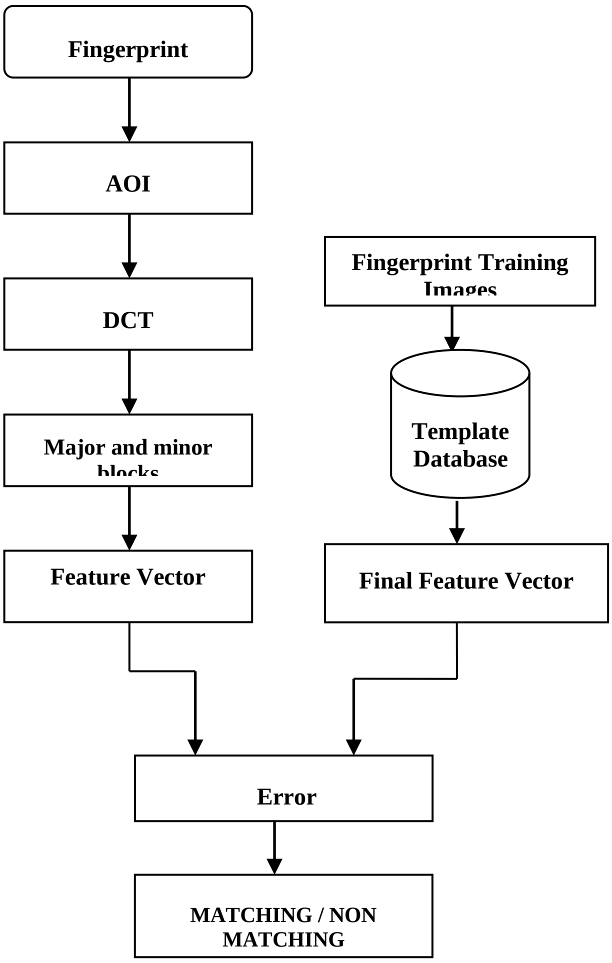

Figure 2. Block Diagram of NMFRS method

variations in DCT coefficients are considered as feature and extracted by segmenting the DCT matrix into non-overlapping blocks. If the block size is minimum the information loss is more at the boundary of adjacent blocks, to reduce the loss the DCT matrix is segmented into minor and major blocks of size 8*8 and 16*16 as shown in Figure 3.

(iv). *Major and Minor blocks:* The image captured depends on the pressure, the corresponding DCT coefficients differ for the same fingerprint taken at different instants, but the variation between DCT Coefficients remains same. The variations in DCT coefficients are considered as feature and extracted by segmenting the DCT matrix into non-overlapping blocks. If the block size is minimum the information loss is more at the boundary of adjacent blocks, to reduce the loss the DCT matrix is segmented into minor and major blocks of size 8*8 and 16*16 as shown in Figure 3.

(v). *Feature Vector:* The variance computed for 27 minor and 9 major blocks are used as feature vector for matching. Let V_{in} and V_m represent the feature vector of the input test image, database respectively and is represented as

$$V_{in} = \{V_{in}(1), V_{in}(2), V_{in}(3)\ldots\ldots V_{in}(36)\}$$

$$V_m = \{V_m(1), V_m(2), V_m(3)\ldots\ldots V_m(36)\}$$

The final Feature Vector (FV) for i^{th} user is obtained by taking the average of all database feature vectors of the i^{th} user using Equation (5).

$$FV_i(j)=\left(\frac{1}{N}\right)\sum_{m=1}^{N}V_m(j) \quad \text{…..……………. (5)}$$

Where,

i=1 to 10, j=1 to 36, N=7.

(vi). *Error:* The error E_i between the test feature vector and database FV is computed using Equation (6).

$$E_i(j)=V_{in}(j)-FV_i(j) \quad \text{………………….. (6)}$$

The average square root value of error is taken as final error E_{im}, and is calculated using the Equation (7).

$$E_{im}=\sqrt{\frac{\sum_{j=1}^{27}(E_i(j))^2+\sum_{j=28}^{36}(E_i(j))^2}{2}} \quad \text{………………. (7)}$$

The average of final error is calculated using Equation (8).

$$E_{imavg}=\left(\frac{1}{N}\right)\sum_{i=1}^{10}E_{im} \quad \text{……………………..………….. (8)}$$

The error is calculated for each user in the database and the minimum error E_{min} is considered for the given database using Equation (9) for fingerprint matching.

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E_{min}= in(E_{1m},E_{2m},……E_{10m})……..……………………..(9)

The image is matched if the error computed satisfies the condition given in Equation (10).

$E_{min} \leq 0.6{*}E_{imavg}$,………………………………..(10)

The user is then marked as recognized genuine user, else false-match. The Percentage Recognition Rate is calculated using Equation (11).

$$PRR = \frac{\sum_{i=1}^{10}\sum_{N=1}^{8} I_{image}(i,N)}{\sum_{i=1}^{10}\sum_{N=1}^{8} I(i,N)} X100 \quad \text{………. (11)}$$

IV. ALGORITHM

Problem definition:

Given test image and large database images, the objectives are

(a) Verify the authenticity of the test image by comparing with the database.

(b) To increase the Percentage Recognition Rate.

Table 1 gives algorithm of NMFRS in which DCT is used to extract the fingerprint feature vectors for the test and database images. Error between the test and database is compared using the threshold value.

Table 1: NMFRS algorithm

- *Input*: Test fingerprint, genuine fingerprint database.
- *Output*: Verified fingerprint.

1. Extraction of AOI around core point by computing variance of blocks for database images.
2. Feature vector extraction of database images, by applying DCT and variance to minor and major blocks of DCT coefficients.
3. Calculation of final feature vector by taking average of all feature vectors for user.
4. Extraction of region around core point by computing variance of blocks for test fingerprints.
5. Feature vector extraction of test fingerprints, by applying DCT and variance to minor and major blocks of DCT coefficients.
6. Calculation of error between test and database fingerprints by computing the difference between the test feature vector and final feature vector of each user.
7. If E_{min} is $\leq$ $0.6{*}E_{imavg}$, then the given test fingerprint is a *genuine* match else it is false match

V. PERFORMANCE ANALYSIS

The accuracy verification in biometrics is measured by the Percentage Recognition Rate. For performance analysis fingerprint database of 10 persons and for each person 8 genuine fingerprint images are considered. Training set is formed by considering 6 and 7 images of each user, Testing Set (TS) is formed by considering the remaining images of each user. Percentage Recognition Rate is calculated and tabulated for various Training Sets, upon user choice, based on minimum error. For TS2 the number of samples are 6 and for TS1 the number of samples are 7. It is observed that in the Table 2, the percentage recognition rate for DB1, DB2 and DB3 is better in the case of TS1 compared to TS2 as the number of samples are more in TS1, comparison of Percentage Recognition Rate of proposed NMFRS method and the existing Traditional DCT [1] and Traditional FFT [12] methods for DB3 of FVC2002 is shown in Table 3. The comparison of TS1 and TS2 for traditional methods and the proposed NMFRS is graphical representation in Figure 4.

Table 2. Comparison of Percentage Recognition Rate for DB1, DB2 and DB3 of fvc2002.

TS	DB1	DB2	DB3
TS=2	75.67%	78.25%	80%
TS=1	100%	100%	100%

Table 3. Comparison of Percentage Recognition Rate.

TS	Traditional DCT	Traditional FFT	Proposed NMFRS
TS=2	71.25%	73.75%	80%
TS=1	96%	100%	100%

It is evident from table 3, that the percentage recognition rate is improved in the proposed algorithm compared to the existing algorithms for both TS1 and TS2.

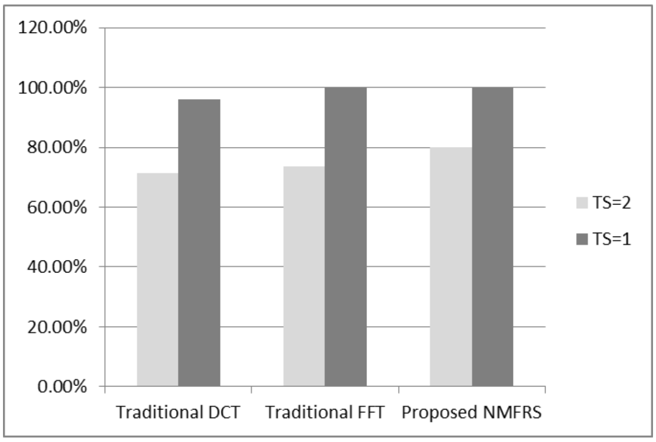

Figure 4. Percentage Recognition Rate of DCT, FFT and NMFRS method.

VI. CONCLUSION

The demand of research in the fingerprint area is growing, as the society is much more concerned about the issues of safety and security than ever. In this paper, Non Minutia Fingerprint Recognition based on Segmentation is proposed. DCT coefficients are obtained for the region around a core point in which more inter-ridge variation is observed and are segmented into major and minor blocks. Feature vector is created by computing variance of major and minor blocks which contain ridge spatial frequency information and ridge orientation information. For each fingerprint sample of a single user the feature vector is computed, the final feature vector is an average of feature vectors of all samples of a user. Final Feature Vector for each user is computed and compared with the test feature vector.

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The experimental results indicate that the performance of the proposed algorithm is better in terms of PRR compared to the traditional existing algorithm.

REFERENCE

1. M P Dale, and M A Joshi, "Fingerprint Matching using Transform Features," *Technology, Education and Networking Conference*, pp. 1-5, 2008.
2. Keming Mao, Zhiliang Zhu and Huiyan Jiang, "A Fast Fingerprint Image Enhancement Method," *Third International Joint Conference on Computational Science and Optimization*, pp 222- 226, 2010.
3. Xuejing Jiang, Ye Liu and Xiaolei Wang, " An Enhanced Location Estimation Approach based on Fingerprinting Technique," *International Conference on Mobile Computing and Communications*, pp 424-427, 2010.
4. Hendrik Lemelson, Sascha Schnaufer and Wolfgang Effelsberg, "Automatic Identification of Fingerprint Regions for Quick and Reliable Location Estimation," *Eighth IEEE International Conference on Pervasive Computing and Communications*, pp 540-545, 2010.
5. Keokanlaya Sihalath, Somsak Choomchuay, Shatoshi Wada and Kazuhiko Hamamoto, " Fingerprint Image Enhancement with Second Derivative Gaussian Filter and Directional Wavelet Transform, " *Second International Conference on Computer Engineering and Applications*, pp 112-115, 2010.
6. Sanna Pasanen, Keijo Haataja, Niina Päivinen and Pekka Toivanen, " New Efficient RF Fingerprint-Based Security Solution for Bluetooth Secure Simple Pairing," *Forty Third Hawaii International Conference on System Sciences*, pp 1-8, 2010.
7. Mohammad O. Derawi, Davrondzhon Gafurov, Rasmus Larsen, Christoph Busch and Patrick Bours, "Fusion of Gait and Fingerprint for User Authentication on Mobile Devices," *Second International Workshop on Security and Communication Networks* , pp 1-6, 2010.
8. Yi Wang and Jiankun Hu, "Global Ridge Orientation Modeling for Partial Fingerprint Identification," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol 1, Issue 99, pp 1-18, 2010.
9. Zhang Yuanyuan and Jing Xiaojun, "Spectral Analysis Based Fingerprint Image Enhancement Algorithm," *International Conference on Image Analysis and Signal Processing*, pp 656-659, 2010.
10. Ashwini R. Patil and Mukesh A. Zaveri, " A Novel Approach for Fingerprint Matching using Minutiae," *Fourth Asia International Conference on Mathematical Analytical Modelling and Computer Simulation*, pp 317-322, 2010.
11. Yanan Meng,"An Improved Adaptive Pre-processing Method for Fingerprint Image," *Second International Conference on Computer Engineering and Applications*, pp 661-664, 2010.
12. Haiyun Xu, R N J Veldhuis, A M Bazen, T A M Kevenaar, A H M Akkermans, and B Gokberk, " Fingerprint Verification using Spectral Minutiae Representations," *IEEE Transactions on Information Forensics and Security*, vol. 4, no.3, pp.397-409, 2009.
13. Yunye Jin, Wee-Seng Soh, and Wai-Choong Wong, "Error Analysis for Fingerprint-Based Localization," *IEEE Communications Letters*, vol 14, no 5, pp 393-395, 2010.
14. Radu Miron and Tiberiu Leţia, "Fuzzy Logic Decision in Partial Fingerprint Recognition," *IEEE International Conference on Automation Quality and Testing Robotics*, pp 1-6, 2010.
15. Chao Chen, David Zhang, Lei Zhang and Yongqiang Zhao, "Segmentation of Fingerprint Image by Using Polarimetric Feature,"*International Conference on Autonomous and Intelligent Systems*, pp 1-4, 2010
16. Yi Hu, Xiaojun Jing, Bo Zhang and Xifu Zhu, "Low Quality Fingerprint Image Enhancement Based on Gabor Filter,"*Second International Conference on Advanced Computer Control*, Vol 2, pp 195 – 199,2010.
17. Jiaojiao Hu and Mei Xie, " Fingerprint Classification Based on Genetic Programming," *Second International Conference on Computer Engineering and Technology*, Vol 6, pp 193 -196, 2010.
18. Raffaele Cappelli, Matteo Ferrara, and Davide Maltoni, "Minutia Cylinder-Code a new Representation and Matching Technique for Fingerprint Recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Issue 99, 2010.
19. Hengzhen Gao, Mrinal K. Mandal, Gencheng Guo and Jianwei Wan, "Singular Point Detection using Discrete Hodge Helmholtz Decomposition in Fingerprint Images,"*IEEE International Conference on Acoustics Speech and Signal Processing*, pp 1094 – 1097, 2010.
20. Jun Ma, Xiao jun Jing, Bo Zhang, and Songlin Sun, "An effective algorithm for fingerprint reference point detection," *Second International Conference on Advanced Computer Control*, Vol 2, pp 200 – 203, 2010.

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L M Patnaik is a Vice Chancellor, Defence Institute of Advanced Technology (Deemed University), Pune, India. During the past 35 years of his service at the Indian Institute of Science, Bangalore, he has over 550 research publications in refereed International Journals and Conference Proceedings. He is a Fellow of all the four leading Science and Engineering Academies in India, Fellow of the IEEE and the Academy of Science for the Developing World. He has received twenty national and international awards, notable among them is the IEEE Technical Achievement Award for his significant contributions to high performance computing and soft computing. His research interests include parallel and distributed computing, mobile computing, CAD for VLSI circuits, soft computing, and computational neuroscience.