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Improve low Quality Fingerprint with DWT Then Apply Minutiae Matching after Feature Extraction

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***Abstract:** Verification of fingerprint is one of the most trustful or successful human being identification systems which are used in various applications like criminal investigation and security related issue of our country. In this paper, DWT using Gaussian filtering minutiae and distance based fingerprint matching system is proposed. The DWT is applied before binarization and thinning process which extend the efficiency of the matching time. Proposed approach is also applicable for low and higher sensor image. The proposed algorithm utilizes the low memory and CPU power. The experimental results show that our approach enhances the quality of images after comparing with original image.*

***Keywords: -** Binarization, DWT, Fingerprint, Gaussian Filter, Thinning*

I. INTRODUCTION

Biometric is an extensively used technology now-a-day to get and match the identity of any person. The biometric is taken from the Greek word Bio it means life and metrics means measurement. The personal verification has become significant human computer interface motion. Countrywide protection, e-commerce and right to use to computer networks are now extremely ordinary where establishing a person's individuality has become essential. In the midst of the biometric characteristics, fingerprint is considered one of the most practical ones. Fingerprint recognition entails a negligible effort from the user does not incarcerate other information than rigorously indispensable for the recognition process and provides comparatively good performance. One more reason for the popularity of fingerprints is the comparatively low price of fingerprint sensors which facilitates easy integration into PC keyboards, smart cards and wireless hardware [1]. Fingerprint categorization is an essential step in any fingerprint identification system because it decreases the time taken in identification of fingerprints. Categorization permits test fingerprint to be matched adjacent to a database. Fingerprint matching system can be categorized into three types:

- Minutiae -based matching
- Correlation-based matching
- Feature-based matching like sweat pores and 3 Dimension matching [2].

The minutiae-based matching is the most fashionable and extensively used technique being the basis of the human based fingerprint similarity. Many fingerprint recognition systems had been proposed but in most of them, pre-processing, alignment and orientation are mandatory. Furthermore, many of these systems entail high resolution fingerprint images, huge memory to store templates, huge memory to match and multifaceted processing. Universal framework for fingerprint identification system is exposed in Figure. 1

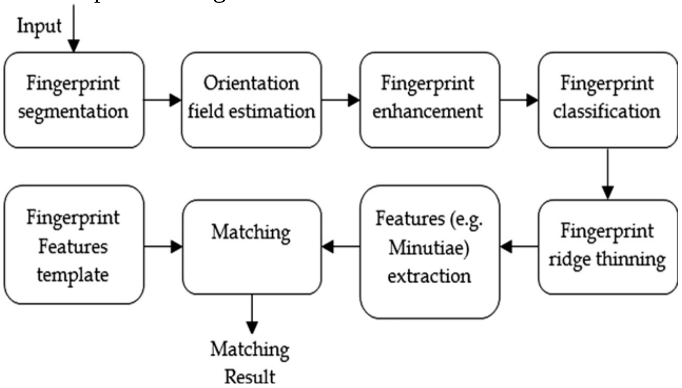


Figure.1 Fingerprint identification system block diagram

In this work, discrete wavelet transforms (DWT) is used before the binarization and thinning process because by doing so the efficiency of matching content time increases, it also increases the quality of fingerprint matching images and requires less memory size to store data.

The organization of the paper is as follows: next section contains literature of the previous works done after that various image compression techniques are discussed with their advantages and demerits and finally conclusion of the presented paper.

II. RELATED WORK

Bharkad and Kokare et al. [3] proposed discrete wavelet packet transform (DWPT) based feature extraction method is illustrated for fingerprint matching. The wavelet packet transform is useful on miniature area of fingerprint image. The performance of wavelet packet disintegration is evaluated on the standard database available at the Website of Bologna University. The idleness of discrete wavelet packet transform is reduced without conciliating the meticulousness. The discrete wavelet packet transform with reduced idleness gives the improved performance over the discrete wavelet transform (DWT), Gabor filter and minutiae based method.

In [4], a hierarchical fingerprints matching method, namely Tangent Distance Sparce Weighted Random sample (TDSWR) method, using sweat pores as fingerprint features, by introducing the TD-Sparse-based method for coarse pore correspondence organization and weighted RANdom Sample Consensus (WRANSAC) for refinement. The proposed method measures the differences between pores based on the residuals obtained by the tangent distance and sparse demonstration technique, which makes the method more robust to noise and local distortions in fingerprints when compared with the existing Direct Pore matching (DP) [5] and Sparse demonstration Direct Pore matching (SRDP) [6] methods. It then establishes one-to-many coarse pore correspondences, and assigns to each correspondence a weight-based on the dissimilarity between the pores in the correspondence. The final pore correspondences are obtained by adopting WRANSAC to refine the coarse pore correspondences. The experimental results demonstrated that the proposed method can more effectively establish pore correspondences and finally reduce the equal error rate (EER) by one order of magnitude in both of the two fingerprint databases used in the experiments (the best improvement on the recognition accuracy is up to 92%). However, the high computational complexity is one of the limitations of this method.

In [7], minutia polygons are used to match distorted fingerprints. A minutia polygon describes not only the minutia type and orientation, but also the minutia shape. This allows the minutia polygon to be bigger than the conventional tolerance box, without losing matching accuracy. Furthermore, the proposed matching method employs an improved distortion model, using a Multi-quadric basis function with parameters. Adjustable parameters make this model more suitable for fingerprint distortion. Experimental results show that the proposed method is two times faster and more accurate (especially, on fingerprints with heavy distortion) than the method in [8].

In [9], a hybrid matching algorithm that uses both minutiae (point) information and texture (region) information is presented for matching the fingerprints. Results obtained shows that a combination of the texture-based and minutiae-based matching scores leads to a substantial improvement in the overall matching performance. This work was motivated by the small contact area sensors provided for the fingertip and, therefore, sense only a limited portion of the fingerprint. Thus, multiple impressions of the same fingerprint may have only a small region of overlap. Minutiae-based matching algorithms, which consider ridge activity only in the vicinity of minutiae points, are not likely to perform well on these images due to the insufficient number of corresponding points in the input and template images.

III. FINGERPRINT IDEIFICATION TECHNIQUES

The image acquired for the matching must be of good quality and it must be free of any type of noise. The less the noise in the fingerprint image the more accurate is the matching. So a good quality fingerprint image is desirable for the improved results of the matching. However it is not always easy to obtain a good quality of fingerprint as they may be corrupted due to the skin problems, scars on fingers. Also because of these cuts and scars a good quality fingerprint image may give false minutiae results .So the fingerprints must be enhanced to get all the features of the fingerprints. There are many techniques that help in enhancing the image of fingerprint which are explained in this paper:

1) Histogram Modeling: The histogram of an image represents the relative frequency of the various gray levels of an image. Using histogram equalization we can get a uniform histogram for the output image .Thus this is a technique for the improvement in the contrast of an image by adjusting the intensity of every gray level of the image. In this technique without affecting the global contrast the lower contrast areas gain a higher contrast [10]. The results of histogram equalization are shown in the following Figure3.

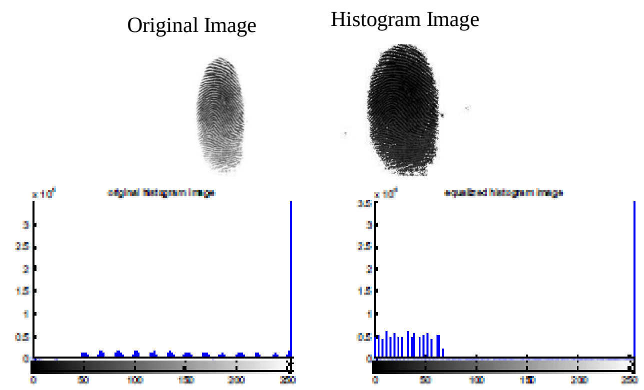


Figure. 3: (a) Original image (b) Histogram image

2) Gabor Filtering: Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function [10] .Gabor filters optimally capture both local orientation and frequency information from a fingerprint image. Once the ridge orientation and ridge frequency are determined, then they are used to construct the Gabor filter. In fingerprint enhancement, Gabor filter can be tuned to specific frequency and orientation values. Gabor filter can enhance the ridges in the direction of local orientation effectively preserving the ridge structure.

IV. PROPOSED METHODOLOFY

4. 1 Fingerprint Enhancement

Extracting minutiae from fingerprint images is one of the most important steps in automatic fingerprint identification and classification. Minutiae are local discontinuities in the fingerprint pattern, mainly terminations and bifurcations. The image acquired from scanner is sometimes not of perfect quality .It gets corrupted due to irregularities and non-uniformity in the impression taken and due to variations in the skin and the presence of the scars, humidity, dirt etc. To overcome these problems, to reduce noise and enhance the definition of ridges against valleys, various techniques are applied as following:

- The first step is to obtain a clear image of the fingerprint.
- Enhancement is carried out so as to improve the clarity of ridge and furrow structures of input fingerprint images based on the estimated local ridge orientation and frequency.
- For grayscale images, areas lighter than a particular threshold are discarded, and those darker are made black.
- The ridges are then thinned from 5-8 pixels in width down to one pixel, for precise location of endings and bifurcations.

Figure: 4 (a) Original image (b) Enhanced

4.2 DWT (Discrete Wave Late Transformation)

In this work only one of DWT derived features is well thought-out, it is vector, which contain energies wavelet coefficients calculate in sub bands at consecutive scales.

The ordinary DWT generates the four sub bands LL, LH, HL and HH at each level of decomposition. The LL sub band gives the near coefficients and the sub bands LH, HL, HH gives the detail coefficients. The LH, HL and HH sub bands gives the horizontal, vertical and diagonal information. In pyramidal DWT, at each level of decomposition only LL sub band is decomposed further. The LH, HL and HH sub bands are not decomposed as shown in (Figure 4.2A) (a), (b) and (c). The discrete wavelet packet study is a generality of discrete wavelet analysis offering a better-off decomposition method. In DWPT detail coefficients are also decomposed into near coefficients and detail coefficients. This offers the richest study; the complete binary tree is produced as shown in Figure 4.2B the Figure 4.2(B) shows the second level of decomposition using DWPT. In Figure 4.2B, a gives the near coefficients and H, V, D gives the detail coefficients. The H, V, D represents the horizontal, vertical and diagonal information. Instead of using LH, HL and HH notations, the H, V, D notations are used to represents the horizontal, vertical and diagonal information [12].

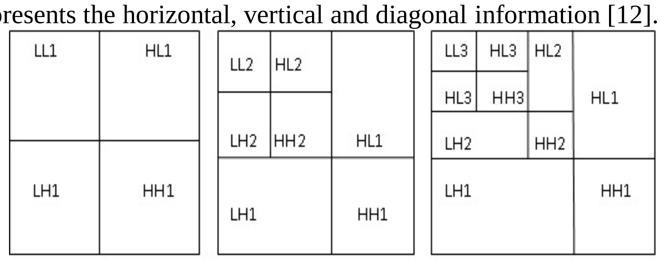


Figure 4.2A Decomposition of an image using DWT (a) Level one (b) level two (c) level three

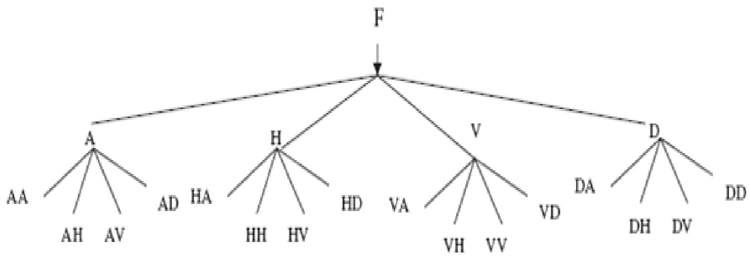


Figure 4.2B Wavelet packet transform with two levels of decomposition

4.3 Binarization

Most minutiae extraction algorithms operate on basically binary images where there are only two levels of interest: the black pixels represent ridges, and the white pixels represent valleys. Binarisation [11] converts a greylevel image into a binary image. This helps in improving the contrast between the ridges and valleys in a fingerprint image, and consequently facilitates the extraction of minutiae. One very useful property of the Gaussian filter is that it contains a DC component of zero, which indicates that the resulting filtered image has a zero mean pixel value. Hence, binarisation of the image can be done by using a global threshold of zero. Binarisation involves examining the grey-level value of every pixel in the enhanced image, and, if the grey-level value is greater than the predefined global.

4.4 Thinning:-

Thinning is a morphological operation which is used to remove selected foreground pixels from the binary images. A standard thinning algorithm from [11] is used, which performs this operation using two sub iterations. The algorithm can be accessed by software MATLAB via the 'thin' operation of the bwmorph() function. Each sub-iteration starts by examining the neighborhood of every pixel in the binary image, and on the basis of a particular set of pixel-deletion criteria, it decides whether the pixel can be removed or not. These sub-iterations go on until no more pixels can be removed.

4.5 Major Steps are followed as:

1. Load Image
2. Read image one by one and pre-processing
3. Start Enhancement with DWT transformation on (current image I and decomposed in band (LLj,LHj,HLj,HHj).
4. Analysis brightness level on the basis of selected LLj band.
5. Apply adaptive intensity filter//smoothed decomposed layers.
6. Apply weighted map and Gaussian filter then smoothing edges.
7. Apply histogram equalization on each decomposed layers.
8. Composed each layers into single image (I_outj) inverse IDWT.
9. End
10. Start feature extraction
11. Read each I_outj
12. Binarization
13. Thinning
14. Core point detection (if found (core<5&&core >150))
15. Called smooth function all possible members as input of function.
16. Minutiae extraction
17. Reject board

18 Find thinned position
19 Also check mask
20 Call bifurcation function
21 Stored result
22 False minutiae detection and reduction
23 Check each condition where value X, max point, mask, thinned will be checked.
24 And stored each iteration
25 Apply distance formula to measure distance.
26 Apply Termination process of false detected points.
27 Store generated features as DB_ftrs [img, j] //store in structure array for each read image.
28 Input query image *Qimg*
29 Goto step 2 and step 10 // follow steps for query image. Store query feature QF_ftr
Call similarity matrix function //for similarity measurement between extracted features
30 Display matched images where

```
if (dist>=0.5)
    disp(Img_j)
      else
        skip
```

Similar image id will display now

V. EXPERIMENTAL RESULT

To investigate the effectiveness of the proposed methodology, there are lots of programming language and simulation are available in the current scenario, but here we chosen a most reputed and high level fourth generation high level language Matlab 2012a with windows 7 Home version for experimental setup, in addition Intel Core I3-2.20 GHz processor, 4 GB RAM, NVIDIA graphics hardware are used. And to perform experimental test a very reputed data set name FVC2004 used.

Main GUI Environment

We have tested result on FVC2004 database version included DB2, DB3 and DB4 and observe follows:

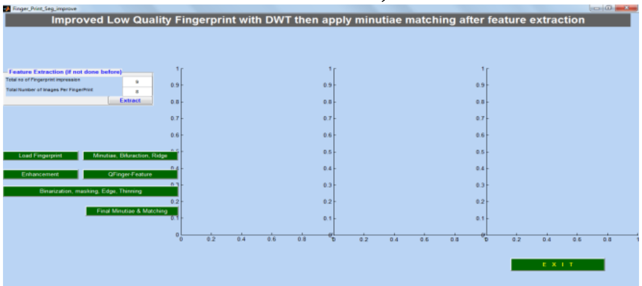
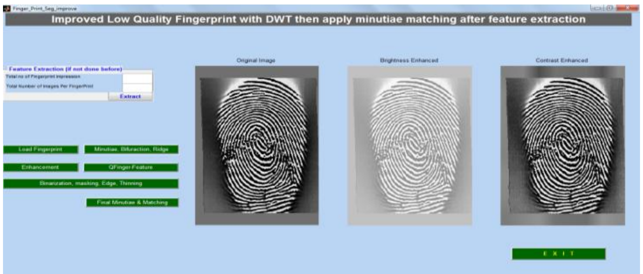
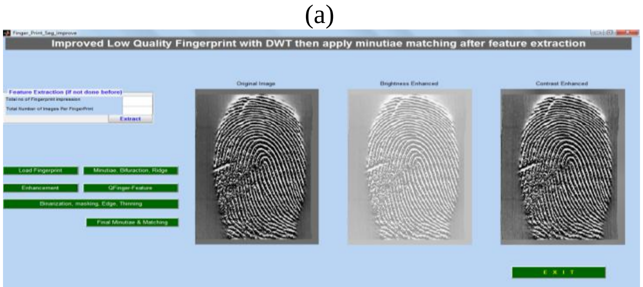


Figure 5.1: feature extraction process

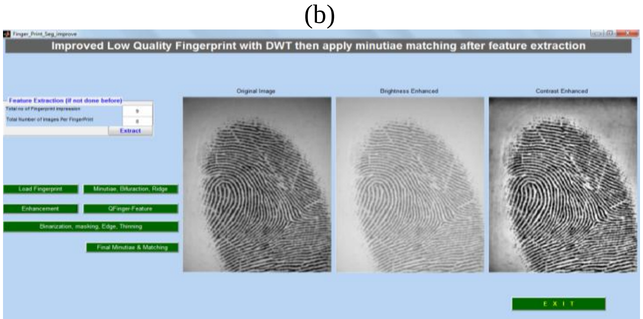
Figure 5.1 shows that the main GUI environment of implemented system, where total number of person's impressions 9 entered in static text1 and number of impression types for single person is 8 entered in static text2. Then after click on extract button the whole preprocess starts like: verify image, enhancement, binarization, masking, thinning, ridge, minutiae etc.



(a)



(b)



(c)

Figure 5.2: Fingerprint enhancement process for different impressions: a) FVC2004_DB3_101_5.tif b) FVC2004_DB3_106_5.tif c) FVC2004_DB4_102_2.tif

Figure 5.2 shows that the enhancement process of fingerprint, where first column shows that the original impression, second impression shows that the brightness of the current impression and third shows that the contrast enhanced image. And this process is as follows for the all impressions.

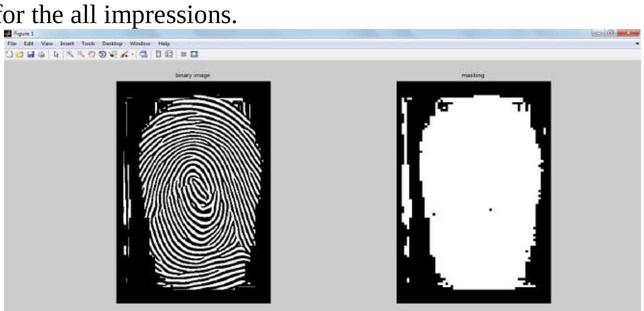


Fig.ure 5.3: Binary and masking process of FVC2004/DB3/101_5.tif

Here figure 5.3 shows that the binarisation and making process for impression FVC2004/DB3/101_5.tif after doing enhancement of images.

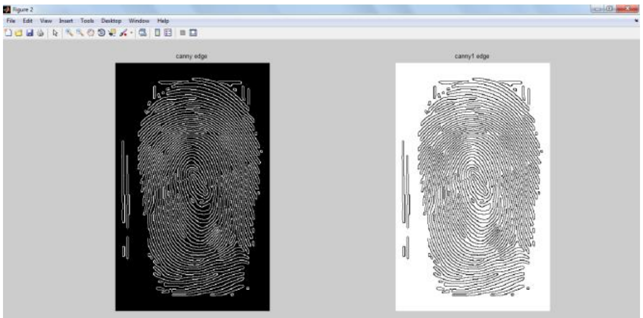


Figure 5.4: Canny edge and inverse process of FVC2004/DB3/101_5.tif

Here Figure 5.4 shows that the edge detection process of FVC2004/DB3/101_5.tif impression, and their inverse process of the same impression.

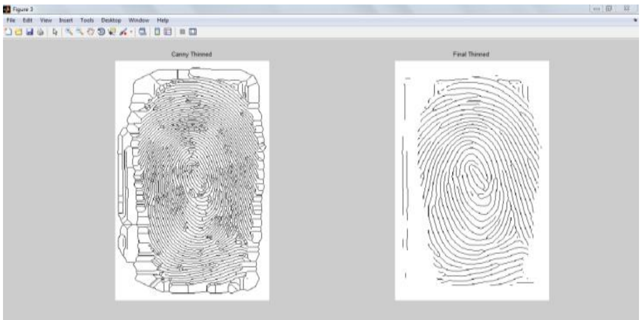


Figure 5.5: Canny Thinned and Re-thinning process of FVC2004/DB3/101_5.tif

Here Figure 5.5 shows that the thinning process of edge detected impression and again re-thinning and remove borders of thinned images, which shows that the better enhancement for the further process.

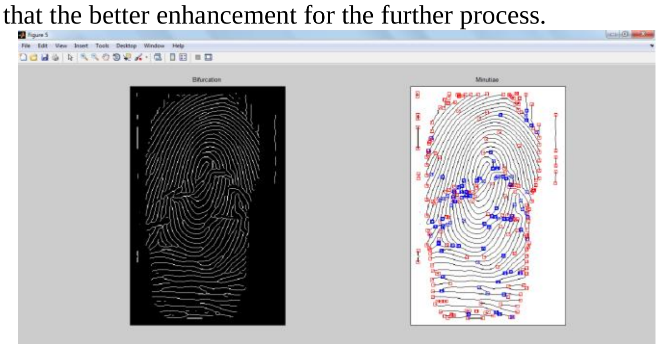


Figure 5.6: Bifurcation and pre-minutiae of FVC2004/DB3/101_5.tif

Here Figure 5.6 shows that the bifurcation and ridge of the impression then its next process is that pre minutiae and detection of the impression. Here we saw that the detected minutiae contain the huge detection and some points positions are detected outside of the image impression. So now it is necessary that the false minutiae should be eliminated from the impression for improvement of accuracy.

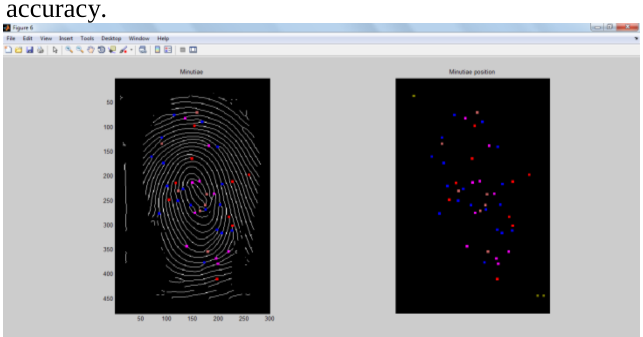
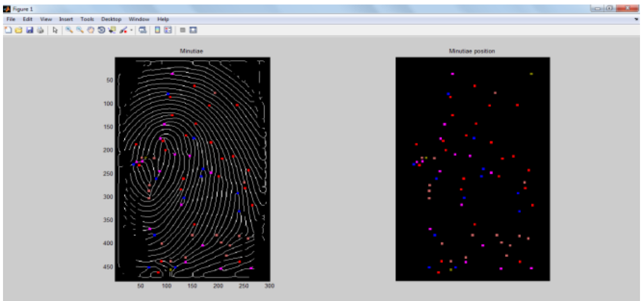


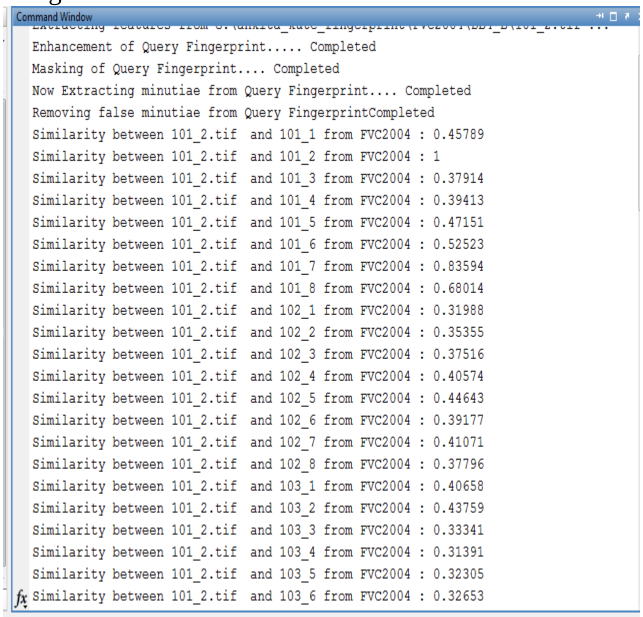
Figure 5.7: Post-minutiae and minutiae detected position

Here Figure 5.7 shows that the final detected minutiae after eliminating of the false detected minutiae, and in next column shows that the x, y correct positions of the detected minutiae. Now matching process and distance based matching starts, where one query finger will start matching from 1st finger impression to last impression.



Finger 5.8: final minutiae and its positions

Here Figure 5.8 shows that the matching process of the minutiae where it will match with the all feature extracted minutiae and distance base matching.



```
Enhancement of Query Fingerprint..... Completed
Masking of Query Fingerprint.... Completed
Now Extracting minutiae from Query Fingerprint.... Completed
Removing false minutiae from Query FingerprintCompleted
Similarity between 101_2.tif  and 101_1 from FVC2004 : 0.45789
Similarity between 101_2.tif  and 101_2 from FVC2004 : 1
Similarity between 101_2.tif  and 101_3 from FVC2004 : 0.37914
Similarity between 101_2.tif  and 101_4 from FVC2004 : 0.39413
Similarity between 101_2.tif  and 101_5 from FVC2004 : 0.47151
Similarity between 101_2.tif  and 101_6 from FVC2004 : 0.52523
Similarity between 101_2.tif  and 101_7 from FVC2004 : 0.83594
Similarity between 101_2.tif  and 101_8 from FVC2004 : 0.68014
Similarity between 101_2.tif  and 102_1 from FVC2004 : 0.31988
Similarity between 101_2.tif  and 102_2 from FVC2004 : 0.35355
Similarity between 101_2.tif  and 102_3 from FVC2004 : 0.37516
Similarity between 101_2.tif  and 102_4 from FVC2004 : 0.40574
Similarity between 101_2.tif  and 102_5 from FVC2004 : 0.44643
Similarity between 101_2.tif  and 102_6 from FVC2004 : 0.39177
Similarity between 101_2.tif  and 102_7 from FVC2004 : 0.41071
Similarity between 101_2.tif  and 102_8 from FVC2004 : 0.37796
Similarity between 101_2.tif  and 103_1 from FVC2004 : 0.40658
Similarity between 101_2.tif  and 103_2 from FVC2004 : 0.43759
Similarity between 101_2.tif  and 103_3 from FVC2004 : 0.33341
Similarity between 101_2.tif  and 103_4 from FVC2004 : 0.31391
Similarity between 101_2.tif  and 103_5 from FVC2004 : 0.32305
Similarity between 101_2.tif  and 103_6 from FVC2004 : 0.32653
```

Figure 5.9: distance matching process

Figure 5.9 shows that the distance between query fingers with all involved stored finger features. Then also match with its minutiae positions like:

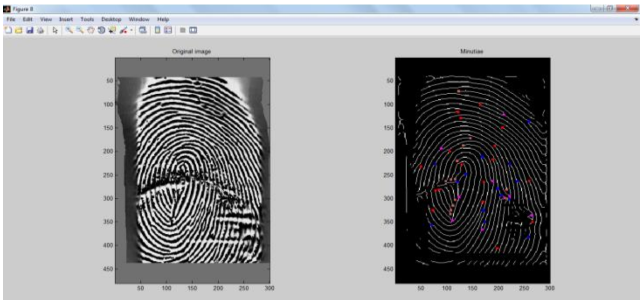


Figure 5.10: minutia of 109_X.tif for all impression of same finger

Here Figure 5.10 shows that the minutiae of all type of finger impression of same fingerprint, which is matched and scanned with the query fingerprint image. Here table 5.1 shows the comparison of FAR of existing and proposed methodology, and it comparative graph shown in figure 5.11 and it secure that the overall performance is much better as to the existing work.

Table 5.1: FAR of FVC2004

False Acceptance Rate		
Dataset	**Existing**	**Proposed**
DB2	0.0682	0.0645
DB3	0.112	0.097
DB4	0.0899	0.075

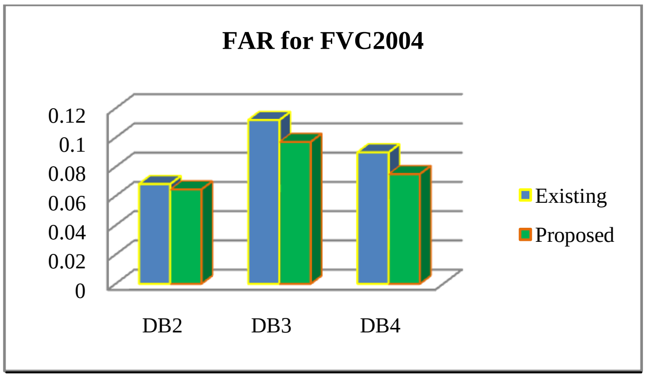


Fig.ure 5.11: FAR for FVC2004

Here table 5.2 shows that the comparison of FRR for existing and proposed work with its comparison graph is shown in figure 5.12.

Table 5.2: FRR of FVC2004

False Rejection Rate		
Dataset	Existing	Proposed
DB2	0.092	0.09
DB3	0.098	0.069
DB4	0.1	0.1

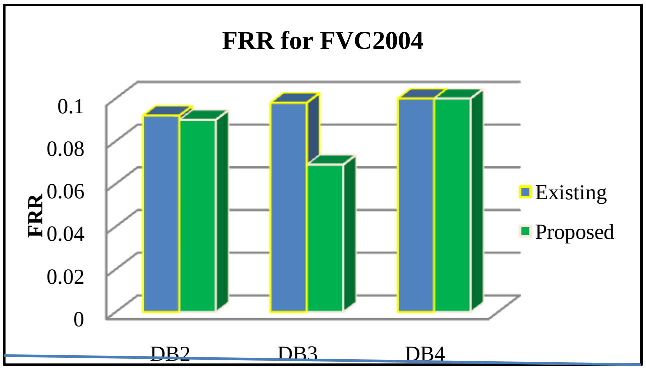


Figure 5.12: FRR for FVC2004

Table 5.3 and Figure 5.13 shows that the comparison accuracy of the proposed method with existing method, where it's clearly shows that the overall accuracy of proposed method is much better than the existing method for the FVC2004 dataset.

Table 5.3: Accuracy of FVC2004

Accuracy FVC2004		
Dataset	Existing	Proposed
All	90	98.5

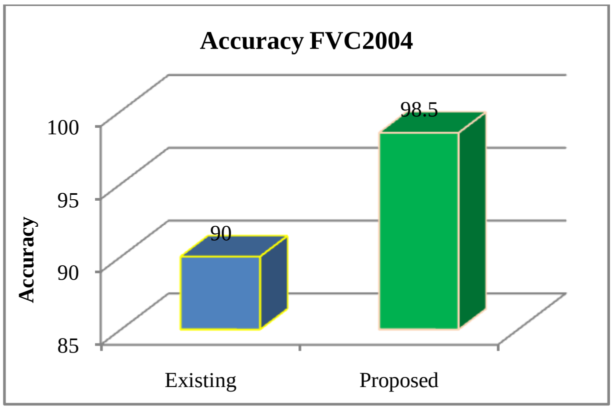


Figure 5.13: Accuracy of FVC2004

The accuracy of the algorithm in the following way: Accuracy in 98.5% where compared with existing 90.02% and the false accepts rates are from 0.06 to 0.097 and the False Reject Rate is from 0.069 to 0.1.

VI. CONCLUSION

The proposed novel approach of fingerprint matching based on distance and minutiae and extends the work for optical sensor, thermal sweeping sensor and synthetic generator. In proposed approach obtained result is as much better than the previous discussed result. One of the reasons is that at preprocessing we perform enhancement with DWT before thinning and binarisation so it's add more efficiency in the matching time, our approach is also work for the low and higher sensor images. In future work,

In future Tree Search (Pruning) techniques can be applied for more efficient result, where each edge/nodes can be connected in depth level of image features. And energy minimization technique can also to be applying for cast as general search problem, consistency of fitness functions etc. In future approaches use any general search and optimization technique like GA, ACO, KNN, SVM etc.

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