ISSN 2229-5518

Noise Elimination and Performance Measure for fingerprint using Median Filter

P.J.Arul Leena Rose[1] and A.Murugan[2]

1.School of Computer Science,FSH,SRM University,Chennai,603203,India

2.Dept of Computer Science,Dr Ambedgar Govt Arts College,Chennai-39,India

Abstract: The aim of this paper is to analyze the low quality fingerprint and enhance it using median filter technique and minutiae detection procedures for fingerprint identification. Different types of noises in the fingerprint images cause greater difficulty for recognizers. As a solution to this problem we employ proven methods for image enhancement. To achieve this first we applied the histogram on 256 grey scale finger print images. Then the histogram-equalized image is obtained. CLAHE with Clip Limit is applied in order to enhance the contrast of small tiles, to eliminate the artificially induced boundaries and to avoid over-saturation of the image specifically in homogeneous areas. Then this image undergoes the binarization process. Further the binarized fingerprint image is filtered with the implementation of the median filtering technique in order to produce the noise free image. The resultant image is further improved by extracting minutiae from fingerprint images. This is one of the most important steps in automatic fingerprint identification and classification. In this paper we employ both median filtering technique and minutiae detection procedures for fingerprint image enhancement. The results are validated by calculating the PSNR value and energy of the enhanced images. The method shows improvement in the minutiae detection process and matching accuracy in terms of energy. The experimental results of PSNR value is very close to the ideal value. In this improved method the energy value is calculated with more accuracy using pixels in the enhanced image.

Key Words : Median Filter Minutiae binarization PSNR value Energy value.

1. Introduction

While biometric identification and authentication provides considerable convenience and also some security benefits over token-based or password-based methods, other security and privacy concerns unique to biometrics must also be taken into account. These include identity theft, cross matching, and the exposure, often

irrevocable of sensitive private information, as well as traceability of individuals. This has stimulated research on the protection of stored biometric data in recent years, primarily focusing on preventing information leakage. Fingerprint recognition is a gifted feature for the biometric identification and authentication systems. The field of biometric authentication is still in its formative years, it's unavoidable that biometric systems will play a significant role in security [1].

In fingerprint minutiae-based matching, features are extracted from two fingerprints and stored as sets of points in a two-dimensional plane. Two options are available for minutiae points, namely endpoints and bifurcations .They are combined, to form up to a total of 35 minutiae points on average in one print [2]. The performance of many feature extraction algorithms depend on the input fingerprint images and usually a fingerprint image enhancement is applied to obtain an enhanced output image, through a set of intermediate steps. Various techniques have been published in the scientific literature, which are used to enhance the grey level of the fingerprint images. The majorities are based on the information about the local ridge structure in term of estimation but their performances decrease drastically when low quality images are used; due to the noise (creases, smudges, and holes). In this paper we present an improved enhancement algorithm using median filter and minutiae extraction that can produce good fingerprint matching for poor quality images, and will calculate the PSNR value and the energy of the enhanced images .

2. Fingerprint characteristics

We have probably looked at our own fingerprint at some point in our life and noticed the *papillary lines* on it. In fingerprint literature, the terms *ridges* and *valleys* are used to describe the higher and lower parts of the papillary lines. The reason we have ridges and valleys on our finger, is the

ISSN 2229-5518

frictional ability of the skin. The formation of the ridges and valleys is a combination of genetic and environmental factors. The DNA gives directions in the formation of the skin of foetus, but the exact formation of the fingerprint is a consequence of random events[3]. This is also the reason why the fingerprints on different finger on the same individual are different, and why identical twins have different fingerprints. The fingerprint features or patterns are of two types namely local and global features. The local features are shown in Figure 1. The local features are ridge termination, ridge island or dot, lake, spur and crossover listed in Table 1. The global features are core and the delta points as shown in Figure 2.

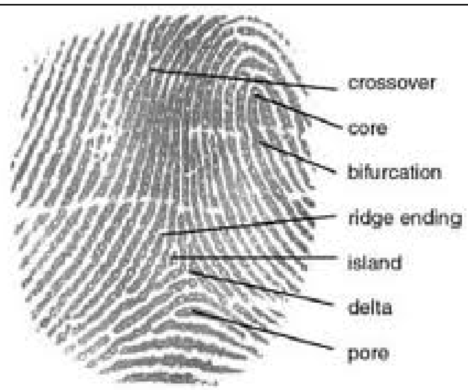


Figure 1: Local Features

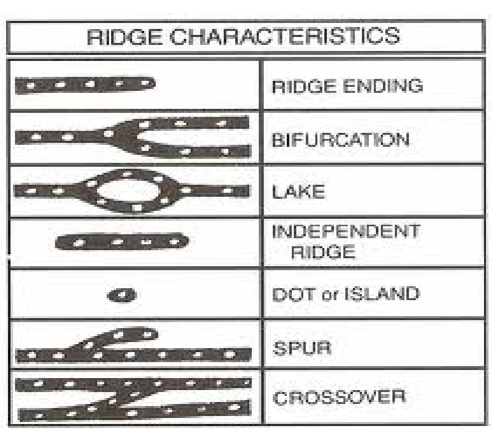
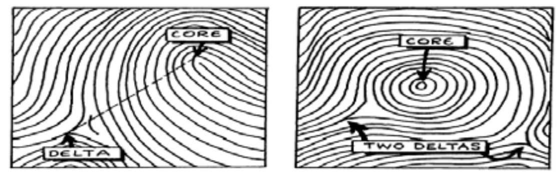


Table 1: Local features representation

Figure 2 : Core and delta point



2.1. Classifications and pattern types

Fingerprints can be divided into three major pattern types such as arches, loops, and whorls, depicted in Figure 3. Loops are the most common fingerprint pattern. These major pattern types can appear in different variations. For example, you can find plain or tented (narrow) arches, right or left loops, and spiral or concentric circles as whorls. Also, the different pattern types can be combined to form a fingerprint, for example a double loop, or an arch with a loop [8].

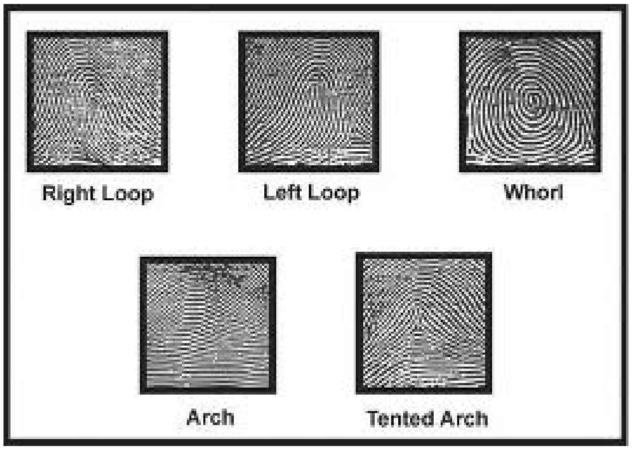


Figure 3 : Fingerprint classes

2.2 Fingerprint Verification system

The general structure of the fingerprint verification is shown in Figure 4.

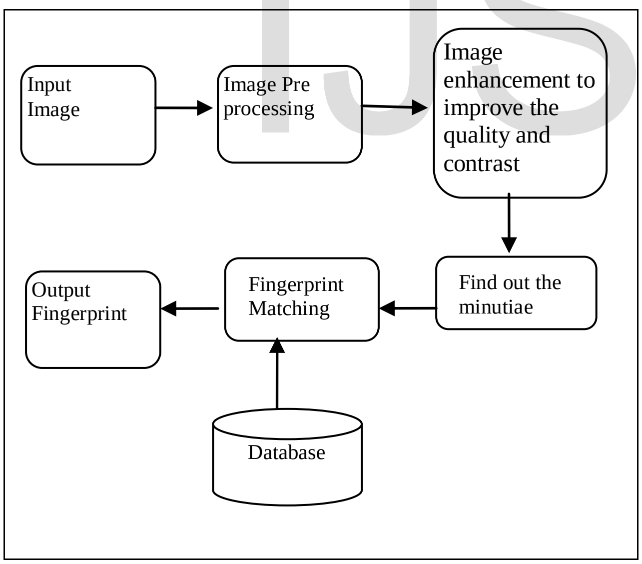


Figure 4 : Structure of Fingerprint Verification system

The structure includes the fingerprint image input, preprocessing, fingerprint enhancement, feature extraction and matching with the stored data for authentication or identification purpose. The system describes that each and every phase followed in the verification process. The fingerprint image is given as input; that is the image is captured from a capturing device. The fingerprint image is preprocessed in order to produce a good quality image (noise-free image). Further, the quality fingerprint image is enhanced for accuracy. Next, the minutiae features are extracted from the enhanced fingerprint image. Finally, the extracted minutiae are matched with the stored data. If the input image is matched then authentication is identified; otherwise authentication is denied. A minutiae based fingerprint matching technique is widely used [4] and the same technique is adopted in this work.

3. Fingerprint images pre-processing

Fingerprint images include unnecessary information such as scars, moist or areas without valuable ridges and furrows. In order to eliminate the redundant information and filter the useful information, a specific process using normalization and binarization are designed.

3.1 Normalization

Histogram equalization is a general

ISSN 2229-5518

process used to enhance the contrast of images by transforming its intensity values. As a secondary result, it can amplify the noise producing worse results than the original image for certain fingerprints. Therefore, instead of using the histogram equalization which affects the whole image, CLAHE (contrast limited adaptive histogram equalization) is applied to enhance the contrast of small tiles and to combine the neighboring tiles in an image by using bilinear interpolation, which eliminates the artificially induced boundaries. In addition, the 'Clip Limit' factor is applied to avoid over-saturation of the image specifically in homogeneous areas that present high peaks in the histogram of certain image tiles due to many pixels falling inside the same grey level range. Additionally, a combination of filters in both domains, spatial and fourier is used to obtain a proper enhanced image.

As a first step of the fingerprint image enhancement process, histogram equalization is applied to enhance the image's contrast by transforming the intensity values of the image (the values in the color map of an indexed image) which are given by the following equation:

$$S_k = T(r_k) = \sum_{j=1}^{k} P_r(r_j) = \sum_{j=1}^{k} \frac{nj}{n}$$

Where S_k is the intensity value in the processed image corresponding to r_k in the input image, and $P_r(r_j)$ =1,2,3…L is the input fingerprint image intensity level. In other words, the values in a normalized histogram approximate the probability of occurrence of each intensity level in the image. Figure 5 shows an example for input image. The differences between the histogram of the normal fingerprint before and after histogram equalization (implemented in the MATLAB Image processing toolbox by function "histeq") are depicted [5] and shown in the Figure 6 and 7 respectively.

Figure 5: Input image

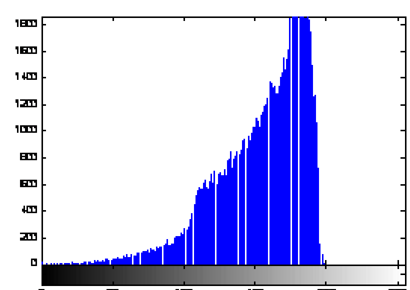


Figure 6 : Histogram of Input image

ISSN 2229-5518

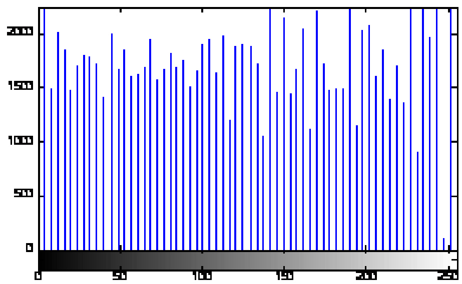


Figure 7 : Histogram of the Enhanced Image

3.2 Binarization

The captured fingerprint image is a grey-scale image [range 0 - 255]. Binarization is the process of transforming the Grey-scale image into the binary image [0,1]. The grey-scale transformations do not depend on the position of the pixel in the image. The binarized image and the corresponding histogram plot are shown in the Figure 8.

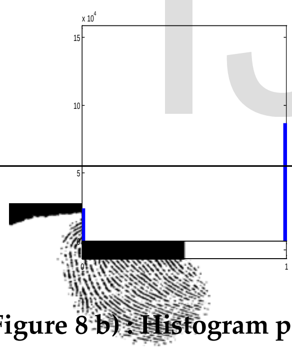


Figure 8 b) : Histogram plot

Figure 8 a) : Binarized image

4. Proposed Algorithm

Fingerprints are imprints formed by friction ridges of the skin and thumbs. They have long been used for identification because of their immutability and individuality. In the recent paper [9] the output is not accurate, it needs more time to process. It is very complex to get the exact result. In order to eliminate the drawbacks of the existing system we propose the new algorithm here. It includes preprocessing, minutiae detection, fingerprint matching and calculation of PSNR values.

The proposed algorithm is given below:

Step 1. Implement the median filter in the Binarized image (InIm).

Step 2. Select the region of interest for filling.

Step 3. Apply the morphological operations.

Step 4. Segment the ridges from the valleys.

Step 5. Detect the minutiae points after filterization

Step 6. Match the selected image with input image.

Step 7. Calculate the PSNR and Energy values.

Step 1.

From a grey image, thresholding can be used to create binary image, which is called binarization. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such a noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image).

Step 2.

A *region of interest* (ROI) is a portion of an image that we want to filter. We define an ROI by creating a *binary mask*, which is a binary image that is the same size as the image wants to process with pixels that define the ROI set to 1 and all other pixels set to 0.

Step 3.

Morphology is the study of the shape and form of objects. Morphological image analysis can be used to perform object extraction, image filtering operations, such as removal of small objects or noise from an image.

Step 4.

The goal of segmentation is to simplify and/or change the representation of an image into more meaningful and easier to analyze image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images.

Step 5.

Minutiae are major features of a fingerprint, using which comparisons of one fingerprint with another can be made. Minutiae include ridge ending, ridge bifurcation, short ridge or independent ridge, spur and crossover or bridge.

Step 6.

We need to match the normalized rotation and the displacement between the database fingerprint image $f(n1, n2)$ and the input fingerprint image $g(n1, n2)$ in order to perform the high-accuracy fingerprint matching. We first generate a set of rotated images $f\theta(n1, n2)$ of the registered fingerprint $f(n1, n2)$ over the angular range $-50^\circ \leq \theta \leq 50^\circ$ with an angle spacing 1°. The rotation angle θ of the input image relative to the registered image can be determined by evaluating the similarity between the rotated replicas of the registered image $f\theta(n1, n2)$ $(-50^\circ \leq \theta \leq 50^\circ)$ and the input image $g(n1, n2)$. Next, we align the translational displacement between the rotation-normalized image $f\theta(n1, n2)$ and the input image $g(n1, n2)$. Thus, we have normalized versions of the registered image and the input image, which are denoted by $f(n1, n2)$ and $g(n1, n2)$. EX-OR logic is used to the match the image.

Step 7.

The ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation is called peak signal to noise ratio (PSNR). To get high accuracy the value of PSNR lies around 21 to 40.

ISSN 2229-5518

4.1 Median Filter

Usually, conventional median filter is the most effective method to remove salt-and-pepper noise and other small artifacts, the proposed median filter can not only do its original tasks, it can also join broken fingerprint ridges, fill out the holes of fingerprint images, smooth irregular ridges as well as remove some annoying small artifacts between ridges. During this phase the grey scale image is transformed into a binary image by computing the mean value of each 32-32 input block matrix and transferring the pixel value to 1 if larger than the mean or to 0 if smaller. The enhancement algorithm has been implemented and tested on fingerprint images from FVC2002. Images of varying quality have been used to evaluate the performance of our approach.

Figure 8: Median Filter

4.2 Region of Interest (ROI)

A *region of interest* (ROI) as shown in Figure 9, is a portion of the filtered image for filling. It is a process that fills a region of interest by interpolating the pixel values from the borders of the region. This process can be used to make objects in an image seem to disappear as they are replaced with values that blend in with the background area.

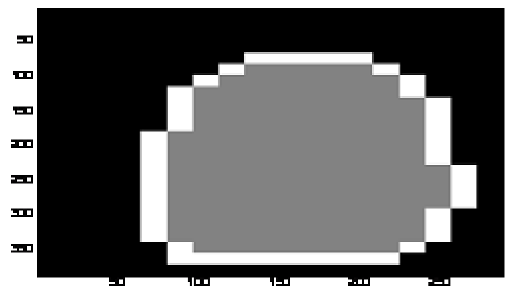


Figure 9: Region of Interest

4.3 Morphological operations

Thinning

Thinning is a morphological operation that is used to remove selected foreground pixels from binary images, somewhat like erosion or opening. It can be used for several applications, but it is

Thinning is normally applied to binary images, and produces another binary image as output.

'thin'

With N = Inf, remove pixels so that an object without holes shrinks to a minimally connected stroke, and an object with holes shrinks to a ring halfway between the hold and outer boundary.

ISSN 2229-5518

'clean'

Remove the isolated pixels (1's surrounded by 0's)

```
0 0 0
0 1 0
0 0 0
```

'spur'

Spur Pixels remove end points of lines without removing small objects completely.

. For example:

```
0 0 0 0            0 0 0 0
0 0 0 0            0 0 0 0
0 0 1 0  becomes   0 0 0 0
0 1 0 0            0 1 0 0
1 1 0 0            1 1 0 0
```

'hbreak'

Remove H-connected pixels. For example:

```
1 1 1            1 1 1
0 1 0  becomes   0 0 0
1 1 1            1 1 1
```

4.4 Ridge Map

After filtering, the next stage is to create a binary representation of the fingerprint that segments the ridges from the valleys and background. This representation is known as ridge map, and it is shown in Figure 10.

The ridge feature map R is used for verification using the following steps :

1. Increase the contrast between the ridges and valleys.

2. Enhance locally ridges along the ridge orientation. The filter window size should be adapted to the local ridge curvature [6]. It should be large enough to increase the signal-to-noise ratio and complete the broken ridges in cuts and creases, and average out noise such as artifacts in valleys.

3. Facilitate feature points detection, and the number of genuine minutiae should be retained same as before enhancement.

4. Do not change the ridge and valley structure and not flip minutiae type.

5. Improve the ridge clarity in the recoverable regions [7], and detect the unrecoverable regions as useless regions for spurious minutiae filtering.

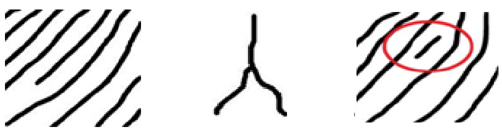
Figure 10: Ridge Map

4.5 Minutiae detection

The major minutiae features of fingerprint ridges are ridge ending, bifurcation, and short ridge(or dot). The ridge ending is the point at which a ridge

ISSN 2229-5518

terminates. Bifurcations are points at which a single ridge splits into two ridges. Short ridges(or dots) are ridges which are significantly shorter than the average ridge length on the fingerprint. Minutiae and patterns are very important in the analysis of fingerprints, since no two fingers have been shown to be identical.



a)Ridge ending b) Bifurcation c) Short ridge

Figure 11: Minutiae features

The most popular method for minutiae extraction is to use a binarized and skeletonized representation of the fingerprint. Extracting minutiae from a ridge map skeleton is fast. The algorithm works by scanning the skeleton and for each pixel a crossing number is calculated. Each ridge pixel can be classified as an intermediate ridge point, a ridge ending or a bifurcation according to its crossing number.

Chen and kuo [10] suggest several heuristics to eliminate spurious minutiae. To remove spikes, any ridges shorter than a given threshold are deleted. To correct broken ridges, small gaps between ridge endings are connected. Finally if many minutiae are detected in a small area, they are discarded because they are likely caused by noise. Nalini k.Radha [11] use morphological operations to detect and remove spikes.

Figure 12 : a) Minutiae detection

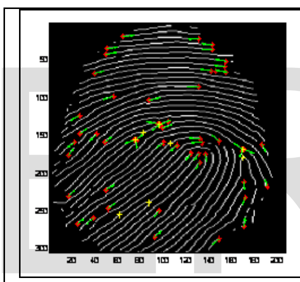


Figure 12 : b) Minutia detection after filterization

5. Experimental Results

This section describes the experimental steps and results obtained. Preprocessing and median filtering were implemented using the MATLAB 7.10 We obtained the input fingerprint image from the fingerprint database FVC 2002(DB1, DB2, DB3, DB4) which occupies 110592 bytes that was under the histogram equalization. The images can be tested with different directions. The PSNR and energy values of

ISSN 2229-5518

Original Image FVC (2002)	Compared image	Matching percentage	PSNR (db)	Energy of enhanced image in pixels
109.1 (DB2)	105.1	37.03	33.63	17404
109.2	105.2	34.21	36.57	17543
109.3	105.3	35.29	35.65	18717
109.4	105.4	30.76	36.85	17586
109.5	105.5	42.85	33.99	17276
109.6	105.6	20.75	34.75	17101
109.7	105.7	29.87	36.15	18227
109.8	105.8	36.36	34.88	17776
110.1	106.1	26.98	34.71	17777
110.2	106.2	26.98	34.18	17580

the enhanced image are calculated as follows.

5.1 PSNR

The phrase **peak signal-to-noise ratio**, often abbreviated **PSNR**, is usually expressed in terms of the logarithmic decibel scale. The formula is

$$PSNR=20*\log10((255^2)/S)$$

where S=Signal

5.2 Energy

Energy is the ratio between accuracy to the product of entire pixels,

$$E = acc/(N(1)*N(2))$$

Where, $acc = acc+ im1(k1,k2)^2$;

N(1),N(2)-n^{th} rows and columns

Image Type	**Size**	**Bytes**	**Class**
Original Image	384*288	110592	Uint8
Median Filtered Image	384*288	884736	Double
Minutiae Detected Image	336*208	559104	Double

K1=1:n(1)

K2=1:n(2)

K1=total number of rows taken

K2=total number of columns taken

Result 1: The PSNR value and Energy value of the enhanced images obtained in our experiment is shown in the table 2.

Table 2 : PSNR Calculation

Table3: Comparison of image before and after noise removal

Result 2

The performance analysis of PSNR value for hundred fingerprint images is shown in figure 13.

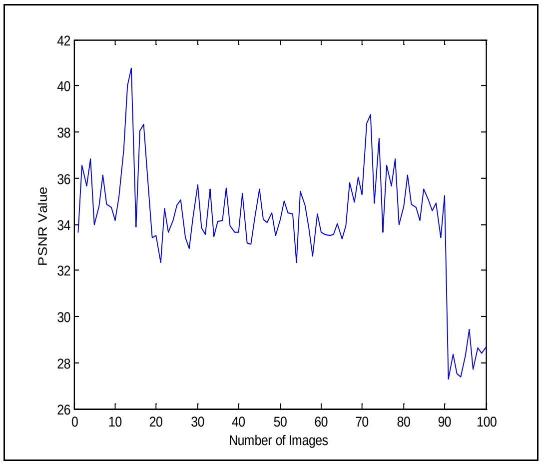


Figure 13: Performance Measure graph

7. Conclusion

Different methods in the public domain for fingerprint image enhancement have been reviewed, and a new methodology allowing superior performance is proposed. In order to avoid specific shortfalls of this process, the procedure follows the application of CLAHE with Clip Limit in order to enhance the contrast of small tiles, to eliminate the artificially induced boundaries and to avoid over saturation of the image specifically in homogeneous areas. In addition, binarized fingerprint image is filtered with the implementation of the median filtering technique in order to produce the noise free image is also proposed. Minutiae detection is obtained by suitable algorithm. Finally PSNR and energy values of the enhanced images reached the high performance. In future this can be implemented with different filters**.**

References

[1] John Chirillo and Scott Blaul, *Implementing Biometric Security,* Wiley Red Books, ISBN: 978-0764525025, April 2003.

[2] Marcus Henriksson, Analys av fingeravtryck, LiTH-ISY-EX-ET-0239- 2002-06-06.

[3]. Tsai-Yang Jea, *Minutiaee Based Partial Fingerprint Recognition*, Ph.D Thesis.

[4] Atipat Julasayvake, Somsak Choomchuay, *An Algorithm for Fingerprint Core Point Detection* IEEE, 1-4244-0779-6/07, 2007.

[5] R. Gonzalez, R. Woods and S. Eddins, *Digital Image Processing Using MATLAB*, Pearson Prentice Hall, 2004.

[6] Q. Xiao and H. Raafat, *Fingerprint image postprocessing: A combined statisticaland structural approach.* Pattern Recognition,24(10):985–992, 199

[7] Jolliffe, I. T. *Principle Component Analysis*. Springer-Verlag, New York, 1986.

[8] Sharat S.Chikkerur, *Online Fingerprint Verification System* M.Sc Thesis.

[9] Rima Belguechi and Christophe Rosenberger, *A minutiae level fusion for AFIS systems*. 17th European signal processing conference, glascow,Scotland August 2009.

[10] Chen and C.Kuo, *A topology based matching algorithm for fingerprint authentication*, Proceeding of the 25th annual IEEE international carnagan conference on security technology, pages 84-87,1991.

[11] Nalini K.Ratha,Shaoyun chen and Anil K.Jain,*Adaptive flow orientation-based feature extraction in fingerprint imaeges*, Pattern Recognition,Vol (28),No:11,pp 1657-1672,1995