STUDY OF FINGERPRINT ENHANCEMENT AND MATCHING

THESIS SUBMITTED IN PARTIAL FULLFILMENT OF THE REQUIERMENT OF THE DEGREE

OF

Master of Technology

IN

Electronics and Instrumentation Engineering

BY

Zeeshan Nawaz

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National Institute of Technology Rourkela
Rourkela, Odisha-769008

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CERTIFICATE

This is to certify that the Thesis titled, **“Study of fingerprint enhancement and matching”** submitted by **Mr. ZEESHAN NAWAZ** bearing roll no. **213EC3224** in partial fulfilment of the requirements for the award of degree of Master of Technology in Electronics and Communication Engineering with specialization in **“Electronics and Instrumentation Engineering”** during session 2014-2015 at National Institute of Technology, Rourkela is authentic work carried out by him under my supervision and guidance.

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DECLARATION

I certify that

1. The work contained in the thesis is original and has been done by myself under the supervision of my supervisor.
2. The work has not been submitted to any other Institute for any degree or diploma.
3. Whenever I have used materials (data, theoretical analysis, and text) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.
4. Whenever I have quoted written material from other sources, I have put them under quotation marks and given due credit to the sources by citing them and giving required details in reference.

ZEESHAN NAWAZ

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ABSTRACT

Fingerprint is the oldest and popular form of biometric identification. Extract Minutiae is most used method for automatic fingerprint matching, every person fingerprint has some unique characteristics called minutiae. But studying the extract minutiae from the fingerprint images and matching it with database is depend on the image quality of finger impression. To make sure the performance of finger impression identification we have to robust the quality of fingerprint image by a suitable fingerprint enhancement algorithm. Here we work with a quick finger impression enhancement algorithm that improve the lucidity of valley and ridge structure based on estimated local orientation and frequency. After enhancement of sample fingerprint, sample fingerprint is matched with the database fingerprints, for that we had done feature extraction, minutiae representation and registration. But due to Spurious and missing minutiae the accuracy of fingerprint matching affected. We had done a detail relevant finger impression matching method build on the Shape Context descriptor, where the hybrid shape and orientation descriptor solve the problem. Hybrid shape descriptor filter out the unnatural minutia paring and ridge orientation descriptor improve the matching score.

Matching score is generated and utilized for measuring the accuracy of execution of the proposed algorithm. Results demonstrated that the algorithm is exceptionally satisfactory for recognizing fingerprints acquired from diverse sources. Experimental results demonstrate enhancement algorithm also improves the matching accuracy.

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- ✓ ***Fingerprint Matching Technique***
- ✓ ***Motivation***
- ✓ ***Objective***
- ✓ ***Thesis Organization***

INTRODUCTION

1.1. Overview

Fingerprint matching is the most universally used individual verification. Finger impression matching is method of verifying the match between two fingerprint of same finger of same person taken at different time or same time. The finger impression of an individual is interesting and stays unaltered over a lifetime. Every finger has the unique pattern, because of the uniqueness of the finger impression it widely used over the century.

The unique pattern of every finger impression is decided by the ridge attribute and relationships among them. Almost 150 characteristics had been identified till now. A ridge is characterized as a solitary bended section, and a valley is the region between two nearby ridge. This features are not evenly distributed over the finger. But most of them are not observed due to impression condition and fingerprint quality. The two most noticeable ridge characteristic are:

1. Ridge ending
2. Ridge bifurcation

Ridge endings are the focuses where the ridge bend ends, and bifurcations are the point where ridge parts from a solitary way to two ways at a Y-junction.

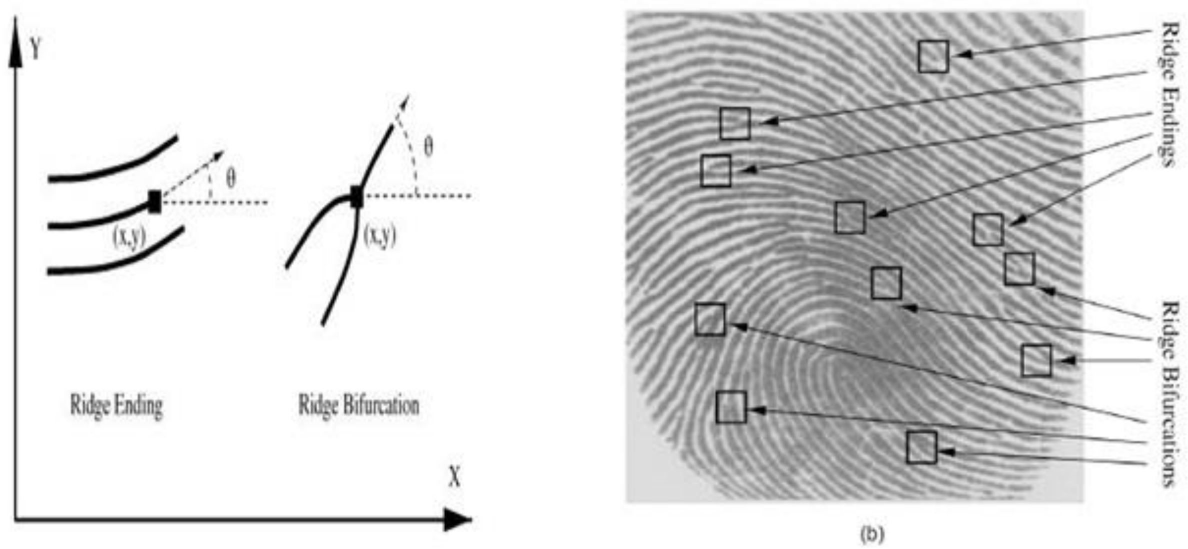


Fig 1.1 (a) minutia characterized (b) minutia in finger image

Finger impression recognition is divided in two parts: 1.verification system and 2. Identification system. A step in finger impression matching is to significantly extract point from the input finger impression. But the ridge structures in poor quality images are not generally all around characterized and, subsequently, they can't be accurately recognized.so we first enhance the sample finger impression then match it with the correct finger impression store in database.

1.2. Fingerprint Enhancement Technique:

An enhancement algorithm take in input finger impression applies an arrangement of middle steps on the data picture, lastly yields the improved picture. Can be done either:

1) Binary ridge images
2) Grey-level images.

Where ridge pixels are doled out an esteem one and non-ridge pixels are appointed a worth zero are known as binary image. By processing a ridge extraction algorithm we can acquired a binary image. In a grey level finger impression, valley and ridge in a nearby neighbourhood frame a sinusoidal-formed plane wave which an all-around has characterized of frequency and orientation.

Here we deal with the grey level image. The flowchart of algorithm:

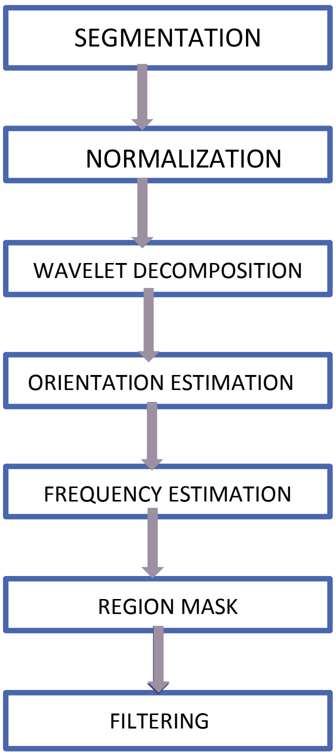


Fig 1.2 enhancement algorithm step

The steps involved in the enhancement algorithm:

1. Segmentation: In this step we separate the foreground region (region of interest) from background region (where lot of noise is present).

2. Normalization: In this step we normalized the sample image, so that we can get pre-defined variance and mean.

3. Orientation estimation: From the normalized image we estimate an orientation image.

4. Frequency estimation: From the orientation and normalized image we calculate the frequency image.

5. Region mask estimation: The normalized image is then divided into recoverable and non-recoverable by classifying each block.

6. Filtering: Then Gobar filter is used to tune the frequency and orientation image and applied in every ridge and valley pixel of normalized image to get the enhanced image.

1.3. Fingerprint Matching Technique:

A crucial part of Automated Fingerprint verification system is the matcher module which makes utilization of finger impression coordinating calculations so as to verify a sample finger impression against layout finger impression(s) for recognizable proof/check

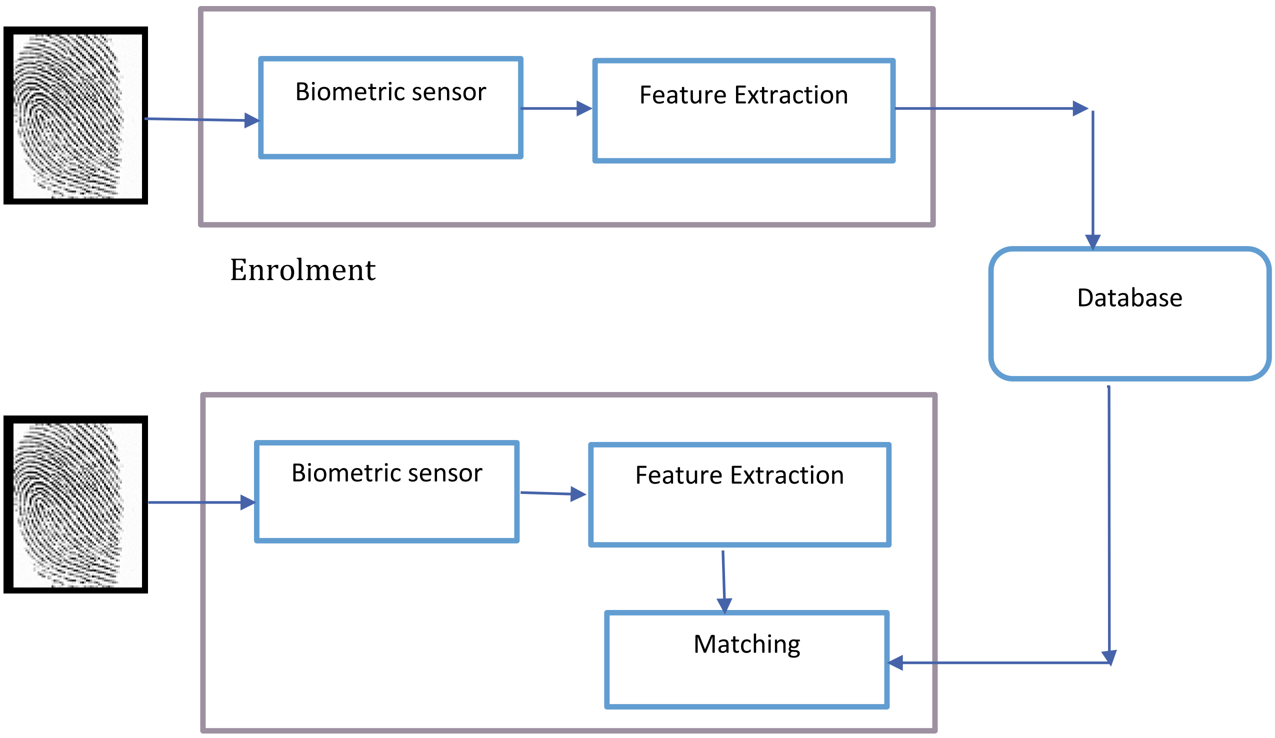


Fig 1.3 Fingerprint matching algorithm step

1.3. Motivation

Fingerprint verification has its huge scope for identifying individual and day by day its important increases. So for fast and accurate fingerprint identification it is necessary, we should built an automatic fast algorithm. For higher accuracy in fingerprint matching we have to enhance the finger impression.

Because most of the time the finger impression we get has lot of noise due to various reason, scaring, dust, skin dryness.so the impression is much distorted and unclear to find the feature.so a pre-processing of the image is required, then we built a matching algorithm for fast minutia finding and then register then point to the image we have in our database to verify the person. But beside environmental reason there are many other factor that effect the matching such as non-linear distortion, variability in displacement, Scanned regions and rotation.so there was always same extra feature we observe or missing feature that create a lot of conflict. So we need an algorithm that can identify that false minutia to get higher an accuracy.

1.4. Objective

The aim of my work is to develop a fast and accurate minutia based fingerprint matching algorithm that can first enhance the sample finger impression then verify it with sample present in database and give us the result by showing us the similarity score.
For this we use hybrid shape and orientation descriptor, where hybrid descriptor filter out the unnatural feature point and orientation descriptor to improve the match score.

1.5. Thesis Organization

Following thesis is divided into 6 part or chapters:

Chapter 1: Introduction
In this part we discuss about the general view about the project process, motivation for this project, objective or aim.

Chapter 2: literature Review
In this part we get an idea about the previous paper in this topic, how much work had been done and what we will do further.

Chapter 3: Fingerprint enhancement technique
In this chapter, we will discuss about the whole process of enhancement. Every main step of the algorithm will be discussed.

Chapter 4: Fingerprint matching technique
In this section, we will discuss about the hybrid descriptor algorithm for better matching and improve match score.

Chapter 5: Result and Discussion
In this chapter, we discuss about the result after enhancement and compare it with the raw sample, we also compare the match score to verify the matched fingerprint.

Chapter 6: conclusion
In this portion, we discuss about the change we get after this algorithm.

CHAPTER 2

LITERATURE SURVEY

LITERATURE SURVEY

Finger impression matching is most widely used method for individual identification and verification. So a number of research had been done in the area of enhancement and matching. Every time the accuracy of matching is a factor to improve.in this paper we are discussing about minutia extraction method of finger impression matching. Following are some of the paper from where we got an idea about the matching and enhancement algorithm.

Fingerprint Techniques by A. Moenssens [1] and *Advances in Fingerprint Technology* by H.C. Lee and R.E. Gaensslen [2] give a basic idea about the biometric technology and relationship and characteristic of ridge and valley. And how it can be used to make personal identification. Danielsson and Q.Z Ye [3] worked with grey scaled image enhancement. Their work is based on concealment of line response with an orientation which create mismatch, they also use rotation invariant operator. ANIL K. JAIN and LIN HONG [4] describe alignment based minutia based matching algorithm where they develop a method which is equipped for discovering the correspondences between input details and template store in database without depending on comprehensive inquiry and can remunerate adaptively for the nonlinear deformation and inaccurate changes between an input sample and a templet. Then D.C. Huang describe purification of characteristic, filtering and noise elimination. He use both foreground and background characteristic. Anil K. Jain and Farshid Farrokhnia [5] proposed segmentation algorithm where systematic filer are selected in which the texture feature are find by applying each filtered image to nonlinear transformation. Shlomo Greenberg and Mayer Aladjem [6] proposed two scheme, one is histogram equalization and binarizition, and second one is use of unique anisotropic filter.

Iwasokun Gabriel Babatunde and Akinyokun Oluwole Charles [7] modified many mathematical model to improve the accuracy where they deal with normalization, image segmentation, thinning, ridge orientation, frequency estimation.

Maio & Maltoni (1997) [8] work on grey scale finger impression where they follow ridge path, they take appoint as a reference and follow to until a local maxima cannot found, that indicate ridge ending or divergent. Liang & Asano (2006) [9] describe the similarity score. Yareg and Amin (2005) [10] had done registration by dividing the image at hexadecimal cell. Then for affine transformation steepest descent algorithm is used, they coined the topic normalized mutual information for registration. Then Tico & Kuosmanen (2003) [11] propose the concept of translation and orientation minutia descriptor, which used to find minutia point by maximum probability value. Chikkeru and Govindaraj (2006) [12] and Kwon al. (2006) [13] introduce δ neighbourhood families, which is used for both similarity score and alignment.

CHAPTER 3
Fingerprint Enhancement

Contents:

- ✓ ***Introduction***
- ✓ ***Algorithm***
  - ➢ ***Segmentation***
  - ➢ ***Normalization***
  - ➢ ***Wavelet decomposition***
  - ➢ ***Orientation estimation***
  - ➢ ***Frequency estimation***
  - ➢ ***Region masking***
  - ➢ ***Filtering***

Fingerprint Enhancement Technique

3.1. Introduction

In this section, we are discussing about the algorithm for improving the quality of fingerprint image. Firstly we have some sample fingerprint image of poor quality in which the ridge are complete distorted.so it is very difficult to find the minutia from this quality of image.so we have to improve the quality before performing minutia extraction algorithm by an enhancement algorithm.so we divide the interest of region in three following categories:

1. Well defined area: In this region ridge and valley can be distinguished, so minutia extraction is possible here.
2. Recoverable area: In this region, ridge and valley are distorted but in very small amount.so this area can be recovered, because it contain most of the information.
3. Unrecoverable area: In this region, large amount of noise is present so it is very difficult to differentiate the ridge and valley.

So, our target is to improve the quality of first two region and neglect the third region, because we have to remove the spurious or unnatural minutia for extraction of proper minutia.

Here, if we use binary image to conduct enhancement algorithm then we have first apply the ridge extraction algorithm in the sample image for ridge finding and as a result many information is lost. So we prefer gray scaled image for enhancement purpose.

Then we apply the following algorithm to the sample input image and finally we get an enhanced image.

3.2. Algorithm

Following intermediate step are performed:

3.2.1 Segmentation

There are two region in a fingerprint: foreground region or background region.

Foreground region mainly contain the ridge and valley. Ridge are the dark, line and valley are the low bright region between two ridge.so in minutia based finger impression we are dealing with this ridge ending and bifurcation, so mainly our region of interest in foreground region. Background region are the outside region that contain a lot of noise, so it is difficult to enhance that part of image. So the grey level variation in the foreground region is high whereas the grey level value of background region is low as compared to foreground. So here we find the variance value by using a block processing method.
In this approach we firstly divide the whole image into X×X size block and then find the value of variance U (k) of every pixel present in the block k by

$$\text{U}(k) = \frac{1}{X^2}\sum_{a=1}^{X}\sum_{b=1}^{X}[\text{I}(a,b) - N(k)]^2 \quad (3.1)$$

$$N(k) = \frac{1}{X^2}\sum_{a=1}^{X}\sum_{b=1}^{X}\text{I}(a,b) \quad (3.2)$$

Where I (a, b) intensity value for the pixel at (a, b) respectively in block k

3.2.2 Normalization

After getting the segmented image we had performed normalization on the ridge structure. The purpose of normalization is to level the variance to a certain value which is enough good for further brightness and contrast improvement.

Let N be the mean of I (a, b) and U (k) is the variance, then H (a, b) be normalized value at pixel (a, b).then the equation will be:

$$H(a,b) = N_0 + \sqrt{\frac{VR_0(I(a,b)-N)^2}{VR}} \; if \; I(a,b) > N \quad (3.3)$$

$$H(a,b) = N_0 - \sqrt{\frac{VR_0(I(a,b)-N)^2}{VR}} \quad otherwise \quad (3.4)$$

Here N_0 and VR_0 are desired mean and variance.

3.2.3 *Wavelet Decomposition*

Our next step is decompose the normalized image by wavelet decomposition. The image is decomposed in one approximation and three sub image. Pyramidal algorithm is used for wavelet transform.

3.2.4 Orientation Estimation

First step for image filtering is image orientation estimation.in every finger impression, the ridge flow a particular path in different direction and form a pattern.so it is necessary to find the orientation of the ridge at a particular point or pixel.
Here we use a modified least mean square algorithm for orientation estimation. Following are the step involved:

1. Firstly we divide the whole normalized image G into X×X size blocked.
2. Then we calculate the gradient of every pixel in the block, d_x (a, b) and d_y (a, b) in x and y direction. Using the horizontal sobal operator, we calculate the d_x (a, b) and using vertical sobal operator we find the d_y (a, b) value.

$$\begin{pmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{pmatrix} \qquad \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}$$

Horizontal sobal operator *Vertical sobal operator*

3. Then for each block we had to find the orientation estimation using following

$$\beta_x(a,b) = \sum_{s=a-\frac{x}{2}}^{a+\frac{x}{2}} \sum_{t=b-\frac{x}{2}}^{b+\frac{x}{2}} 2\,\lambda_x(s,t)\,\lambda_y\,(s,t) \tag{3.5}$$

$$\beta_y(a,b) = \sum_{s=j-\frac{x}{2}}^{i+\frac{x}{2}} \sum_{t=j-\frac{x}{2}}^{j+\frac{x}{2}} 2\,\lambda_x(u,v)\,\lambda_y\;\;(s,t) \tag{3.6}$$

$$\omega(\mathrm{a,b}) = \frac{1}{2}\tan^{-1}\left(\frac{\beta_y(\mathrm{a,b})}{\beta_x(\mathrm{a,b})}\right) \tag{3.7}$$

Here ω (a, b) is the least square estimate at pixel (a, b).

4. As there is lot of noise, the ridge are not clear, so orientation estimation may be incorrect. There by we use a low pass filter to modify the orientation.so for this purpose we convert is into continuous vector,

$$\theta_x(a,b) = \cos\big(2\omega(a,b)\big) \tag{3.8}$$

$$\theta_y(a,b) = \sin\big(2\omega(a,b)\big) \tag{3.9}$$

Here Θ_x and Θ_y are the component of vector along x and y direction.

5. Then we calculate the Gaussian low pass filter as follow:

$$\theta_x^{'}(\mathrm{a,b}) = \sum_{S=-X_\theta/2}^{X_\theta/2} \sum_{T=-X_\theta/2}^{X_\theta/2} W(\mathrm{s,t})\theta_x(\mathrm{a}-sw, \mathrm{t}-bw) \tag{3.10}$$

$$\theta_y^{'}(\mathrm{a,b}) = \sum_{S=-X_\theta/2}^{X_\theta/2} \sum_{T=-X_\theta/2}^{X_\theta/2} W(\mathrm{s,t})\theta_y(\mathrm{a}-sw, \mathrm{b}-tw) \tag{3.11}$$

Here W is the Gaussian filter with size $X_\Theta \times X_\Theta$

6. Then at pixel (a, b),the orientation field R, after smoothing is

$$\mathrm{R(a,b)} = \frac{1}{2}\tan^{-1}\left(\frac{\theta'_y(\mathrm{a,b})}{\theta'_x(\mathrm{a,b})}\right) \tag{3.12}$$

Fig (3.6) is show the orientation field.

3.2.4 Frequency estimation

Another intrinsic property finger impression is frequency estimation, where the occurrence of ridge after a particular space form a ridge frequency and form a sinusoidal wave. Till now we have normalized image G and orientation image O, then we now calculate frequency estimation:

1. Normalized image G is divide into W×W sized blocked.
2. Secondly for ridge coordinate calculate the oriented window.

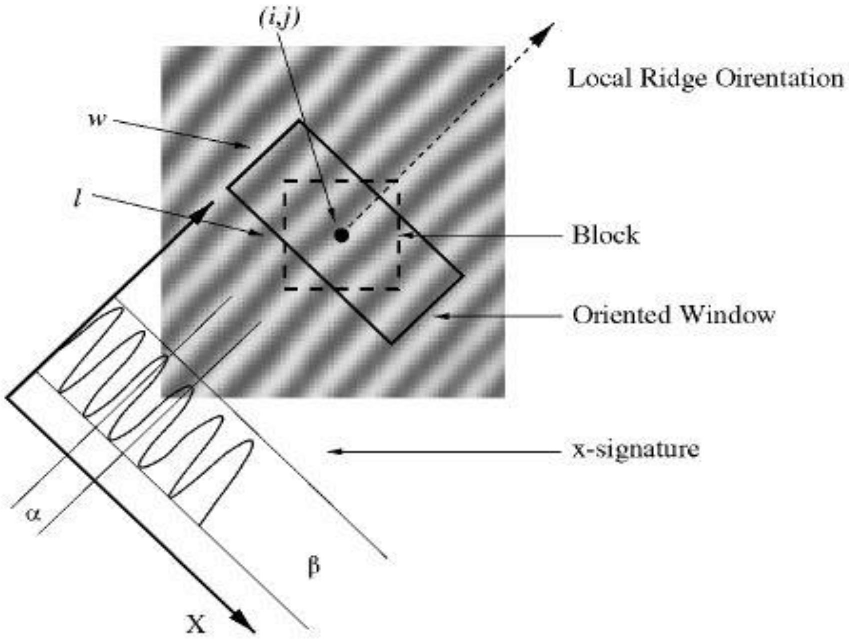


Fig 3.1 x-signature

3. At pixel (a, b) center for every block, calculate the *x-signature* of ridge and valley, then

$$Z[k] = \frac{1}{X}\sum_{d=0}^{X-1} H(\mathrm{s},\mathrm{t}) \qquad k = 0,1,2.......,l-1 \qquad (3.13)$$

Where, *s and t*

$$s = a + \left(d - \frac{X}{2}\right)\cos R(\mathrm{a},\mathrm{b}) - \left(k - \frac{L}{2}\right)\sin R(\mathrm{a},\mathrm{b}) \qquad (3.14)$$

$$t = b + \left(d - \frac{X}{2}\right)\sin R(\mathrm{a},\mathrm{b}) + \left(\frac{L}{2} - k\right)\cos R(\mathrm{a},\mathrm{b}) \qquad (3.15)$$

Let, Ʈ (a, b) number of pixel between two consecutive ridge. Then the frequency will be Q (a, b) =1/Ʈ (a, b).

4. Generally the finger impression image of particular resolution, have a certain range of frequency .so ,if the frequency estimation is showing a value out of this range then it assigned -1 value to confirm it as invalid.
5. The block where we get a minutia or frequency value out of range from an invalid sinusoidal wave need an interpolated frequency value. And this is achieved by neighboring block frequency which is well defined. Then the interpolation

$$Q'(\mathrm{a,b}) = \begin{cases} Q(\mathrm{a,b}) & \text{if } \mathrm{Q(a,b)} \neq -1 \\ \dfrac{\sum_{s=-X_Q/2}^{X_Q/2} \sum_{t=-X_Q/2}^{X_Q/2} W_g(\mathrm{s,t})\kappa(Q(\mathrm{a}-sX, \mathrm{b}-t\mathrm{X}))}{\sum_{s=-X_Q/2}^{X_Q/2} \sum_{t=-X_Q/2}^{X_Q/2} W_g(\mathrm{s,t})\eta(Q(\mathrm{a}-sX, \mathrm{b}-t\mathrm{X})+1)} & Otherwise \end{cases}$$

$$\kappa(\mathrm{x}) = \begin{cases} 0 & if \;\; x \leq 0 \\ x & otherwise \end{cases} \tag{3.17}$$

$$\eta(x) = \begin{cases} 0 & if \;\; x \leq 0 \\ x & otherwise \end{cases} \tag{3.18}$$

W_g is the Gaussian kernel.

3.2.4 Region Mask

As we discussed earlier that some portion are recoverable and some are unrecoverable. So for classification the pixel into this two category we are dealing with the shape of the sinusoidal wave. Three feature are to categorized of the wave: variance (φ), frequency (Ɛ) and amplitude (Ψ).then we find the x-signature of pixel (a, b) at center, and compute the following:

1. Ɛ = 1/Ʈ(a, b), Ʈ(a, b)is the average number of pixel in between two consecutive ridge
2. Ψ =(height of the peak – depth of the valley)
3. $$\varphi = \frac{1}{L}\sum_{a=1}^{L}\left(Z[\mathrm{a}] - \left(\frac{1}{L}\sum_{a=1}^{L} Z[\mathrm{a}] \right) \right)^2 \tag{3.19}$$

By all this three feature we categories the different type of finger impression into recoverable and unrecoverable. If a block with a center (a, b) is recoverable, we assigned it as R(a, b)=1 ,otherwise R(a, b)=0. After all the process we get an image R where we compute the recoverable region and if the percentage of the recoverable is smaller than a minimum threshold, then we reject that sample image or if the image pass this stage then it will be allowed to the next process.

3.2.4 Filtering

The pattern of ridge and valley with all around characterized orientation and frequency in a finger impression image is provide us many useful information to remove the desirable noise and enhance the image quality.

But the sinusoidal wave change is very slow in local orientation.so we need a filter to remove the remaining unwanted noise without disturbing the pattern of ridge and valley for this Gobar filter is best among all because it is orientation and frequency selective properties. And also optimal resolution in frequency and spatial domain.

Gobar filter has the following equation:

$$F = (\mathrm{u}, \mathrm{v} : \theta, \mathrm{q}) = \exp\left\{-\frac{1}{2}[\frac{u_\theta^2}{\delta_u^2} + \frac{v_\theta^2}{\delta_v^2}]\right\}\cos(2\pi q u_\theta) \quad (3.20)$$

$$u_\theta = u\cos\theta + v\sin\theta \quad (3.21)$$

$$v_\theta = -u\sin\theta + v\cos\theta \quad (3.22)$$

Here Θ is the orientation of the filter and *q* is the frequency of the wave δ_x and δ_y is the space constant along X and Y direction. Here selection the value of the space constant or standard deviation is very important. Higher the value standard deviation remove the noise more accurately but create some spurious or unnatural ridge and valley. On the other hand, if the value is selected less than the noise removal is not so effective but it don't create any spurious.so a moderate value is chosen. Then finally the enhanced image equation is:

$$En(\mathrm{a},\mathrm{b}) = \begin{cases} 255 & \text{if } M(\mathrm{a},\mathrm{b}) = 0 \\ \sum_{s=-X/2}^{X/2} \sum_{t=-X/2}^{X/2} F(\mathrm{s},\mathrm{t} : \mathrm{R}(\mathrm{a},\mathrm{b}), \mathrm{Q}(\mathrm{a},\mathrm{b}), \mathrm{H}(\mathrm{a}-s, \mathrm{b}-t) & \text{otherwise} \end{cases} \quad (3.23)$$

Where R is the orientation image, H is the normalized image and Q is the frequency image

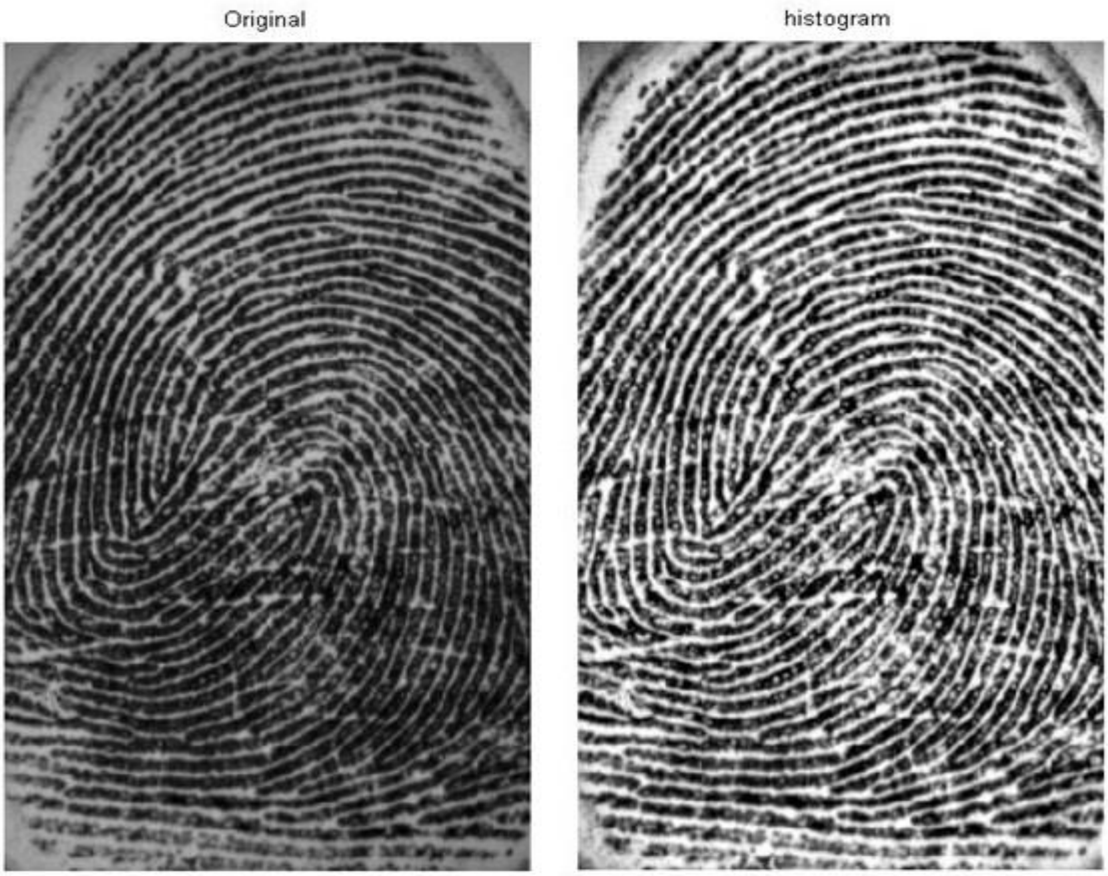


Fig: 3.2 (a) Sample image and (b) After His

Fig 3.3 The result (a) Normalization (b) Thinning

Fig 3.4 comparison of ridge end point in (a) enhanced image (b) sample image

Fig 3.5 comparison of ridge bifurcation point in (a) enhanced image (b) sample image

Fig 3.6 comparison of ridge orientation in (a) enhanced image (b) sample image

CHAPTER 4
Minutia Matching

Contents

- ✓ ***Introduction***
- ✓ ***Minutia Extraction***
- ✓ ***Registration***
- ✓ ***Matching Algorithm***

Minutia matching

3.1. Introduction

For finger impression verification and identification, our main focus is on minutia extraction and matching it with the stored database. Matching method are following three type:

1. Correlation method: In this matching algorithm, two finger impression (sample and database finger impression) are superimpose and calculate the correlation at every pixel for different rotation and displacement.
2. Minutia extraction method: In this matching algorithm, minutia are extracted from two finger impression and used to align and for pairing between the two image pixel.
3. Feature based method: in this matching algorithm, the feature except the minutia, such as frequency, ridge shape, etc. are used to alignment and matching.

Here, we deal with minutia extraction and matching algorithm for matching and calculating the matching score. Firstly we deal with the extraction and then registration of minutia point. But there are many missing minutia and spurious, so the accuracy is always a problem, so here we use a hybrid descriptor to remove this spurious and orientation descriptor for improving the matching score.

3.2. Minutia extraction:

After getting the thinned image from the enhancement process, every pixel w is processed to find the minutia point. For this, we are used 8 neighborhood in anti-clock direction in order to find the *Crossing number*,

$$PT(\mathrm{w}) = \frac{1}{2} \sum_{a=1.....8} \left| val(\mathrm{w}_{(\mathrm{a} \ \mathrm{mod} 8)}) - val(\mathrm{w}_{a-1}) \right| \tag{4.1}$$

Here val € {0, 1}, from this minutia can find, where *PT*=1, indicating the ridge ending and *PT*= 3 indicate ridge bifurcation.

Then this minutia are represented by three parameter called *minutia triplet,* m_i={x,y,ϴ},where x and y are the coordinate along x and direction. And ϴ is the angular direction.

For matching we concentrate on one to one pairing, minutia point of test image

A {m_{A1} , m_{a2},………………m_{Ai}} here m_{Ai}={x_{Ai},y_{Ai},$ϴ_{Ai}$},

Minutia point of strode image

B {m_{B1} , m_{B2},………………m_{Bi}} here m_{Bi}={x_{Bi},y_{Bi},$ϴ_{Bi}$},

By this minutia set, we have to find the paining, but there are lot of unnatural point or missing minutia, so the accuracy is affected.

3.2. Registration:

Here to find the minutia pair, we overlay the sample image to the database image, so this purpose global registration is necessary. For global registration, here we use the affine transform:

$$\begin{bmatrix} x_n \\ y_n \end{bmatrix} = \begin{bmatrix} \cos(\phi_\Delta) & -\sin(\phi_\Delta) \\ \sin(\phi_\Delta) & \cos(\phi_\Delta) \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} x_\Delta \\ y_\Delta \end{bmatrix} \qquad (4.2)$$

$$\phi_n = \phi - \phi_\Delta \qquad (4.3)$$

Here ϕ_Δ is the difference orientation and (X_Δ and Y_Δ) is the difference in displacement.

Here we use an orientation descriptor which is translation and orientation invariant to calculate the max probabilistic value:

$$[s,t] = \arg\ \max ss(p_{A_i}, p_{A_i}) \qquad (4.3)$$

$$Z(p_{A_i}, p_{B_j}) = \frac{ss\left(p_{A_i}, p_{B_j}\right)^2}{\left(\sum_{k=1}^{q} ss\left(p_{A_i}, p_{B_j}\right) + \sum_{l=1}^{p} ss\left(p_{A_i}, p_{B_j}\right)\right)} \qquad (4.4)$$

$$ss(p_{A_i}, p_{B_j}) = (1/\mathrm{K}) \sum_{d}^{l} \sum_{c}^{k} \exp\left(\frac{2(\min\left|\phi_{c,d}^{A_i} - \phi_{c,d}^{B_j}\right|, \pi - \left|\phi_{c,d}^{A_i} - \phi_{c,d}^{B_j}\right|)}{\pi\ \partial}\right) \qquad (4.5)$$

Where the orientation descriptor has a total of K sample points distributed as L concentric circles having Kc points (i.e. possibly differing number per circle) with equidistant angular Fingerprint Matching using A Hybrid Shape.

3.2. Matching algorithm:

After performing the orientation descriptor, now we have the minutia pair, but this descriptor not able to find minutia pair in the case of partial impression coverage, minutia pair near edge.so we proposed an improved algorithm, so that every minutia pair can participate in the sim score:

So it is achieved by Gaussian weighing of above equation:

$$ss^*(p_{A_i}, p_{B_j}) = ss(p_{A_i}, p_{B_j}) \times \exp(-\max(0, \nabla_{\text{cut-off}} - \nabla_{g-count}).\partial_{ss}) \quad (4.6)$$

Where $\nabla_{\text{cut-off}}$ is the cut-off point, the sample below this point are weighed, $\nabla_{\text{g-count}}$ is the total number of good samples.

Then, after getting the filtered minutia pair, our next goal is asses the similarity of minutia pair. For this we use δ-neighborhood families. This structure defined the following field:

1. Distance S: the separation a neighborhood is far from the reference minutia.
2. Angle $\measuredangle$: the angle between the reference and neighborhood minutia.
3. Orientation ϕ: difference between the reference direction and neighborhood direction.
4. Texture T: orientation based descriptor test set for an area minutia utilized to quantify the area introduction closeness with the reference minutia for a given specimen file.

Then the structure:

$$n\chi(p_{A_i}) = \left\{\left\{S_{A_i(1)}, \measuredangle_{A_i(1)}, \phi_{A_i(1)}, \{\mathrm{T}_{A_i(1)}\}\right\}, \ldots\ldots\ldots\ldots, \{s_{A_i(\chi)}, \measuredangle_{A_i(\chi)}, \phi_{A_i(\chi)}, \{\mathrm{T}_{A_i(\chi)}\}\}\right\} \quad (4.7)$$

For comparing the neighborhood element for the sample minutia pair, we calculate the difference of the first three field:

$$S_{dif\,(p_{A_i}, p_{B_i})}(\mathrm{x}, \mathrm{y}) = \left| S_{A_i(x)} - S_{B_i(\mathrm{y})} \right| \quad (4.8)$$

$$\measuredangle_{dif(p_{A_i},p_{B_i})}(\mathrm{x},\mathrm{y}) = \left|\measuredangle_{A_i(x)} - \measuredangle_{B_i(\mathrm{y})}\right| \tag{4.9}$$

$$\phi_{dif(p_{A_i},p_{B_i})}(\mathrm{x},\mathrm{y}) = \left|\phi_{A_i(x)} - \phi_{B_i(\mathrm{y})}\right| \tag{4.10}$$

And for the calculation of the difference in orientation of neighboring minutia, we are using:

$$\mathrm{T}_{dif(p_{A_i},p_{B_i})}(\mathrm{x},\mathrm{y}) = \left|\mathrm{T}_{A_i(x)} - \mathrm{T}_{B_i(\mathrm{y})}\right| \tag{4.11}$$

Now a suitable method is required for scoring minutia pair. But every neighborhood do not contain the same number of minutia pair, so here we use a greedy algorithm. Where we take one neighborhood and find it best match considering the pre-specified value of affine transform.

For a candidate minutia pair (p_{A_i}, p_{B_j}), the matched neighborhood pair full fill the set index (x_k, y_l) is:

$$sim_{\chi}(p_{A_i}, p_{B_j}) = \sum_{m,.n} (\Omega(x_k, y_l) + \gamma \mho(x_k, y_l)) \tag{4.12}$$

The, after getting the all candidate minutia pair, now we can calculate the similarity score:

$$sim(A,B) = \frac{n_M (\sum_{(\mathrm{i,j})} sim_{\chi}(p_{A_i}, p_{B_j})).(\sqrt{ss_{\max}}}{n_{A.}n_B} - D_{SC} \tag{4.13}$$

$$ss_{MAX} = \arg\ \max\ ss^*(p_{A_i}, p_{B_j}, I(\mathrm{A}_i, B_j)) \tag{4.14}$$

SSMAX is defined in the above. n_M is the number of matching pair n_A and n_B is the minutia pair overlap in region A and B.

CHAPTER 5

Result and Discussion

Result and Discussion

Here we have FCV2002 image database where 4 type of finger impression of different 4 finger, Firstly we take a finger impression image and perform the enhancement process to get and enhanced image and find the minutia point and compare it with the minutia point found on the image without enhancement process. There is clear indication that the image without enhancement have many false minutia point or missing minutia point. The normalized image, thinning image, enhanced image, ridge ending, ridge bifurcation and ridge orientation of both the image with enhancement and without is shown side by side.

Secondly, we store with 4 finger impression image of different finger in database, from the 4 image we take as test image. After that we enhanced each image in the database and find its minutia point and calculate its similarity score with the sample image. The best match image shows the highest score indicating its verification and identification.

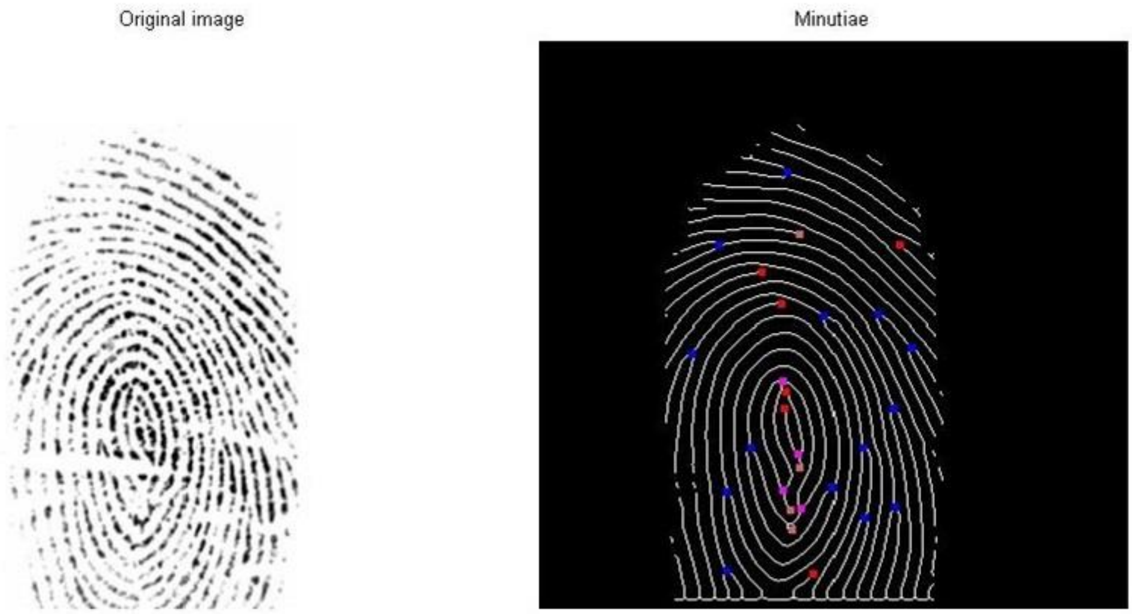


Fig 5.1 (a) Test image (b) minutia of test image

Fig 5.2 (a) sample image (1) (b) result of sample image(1)

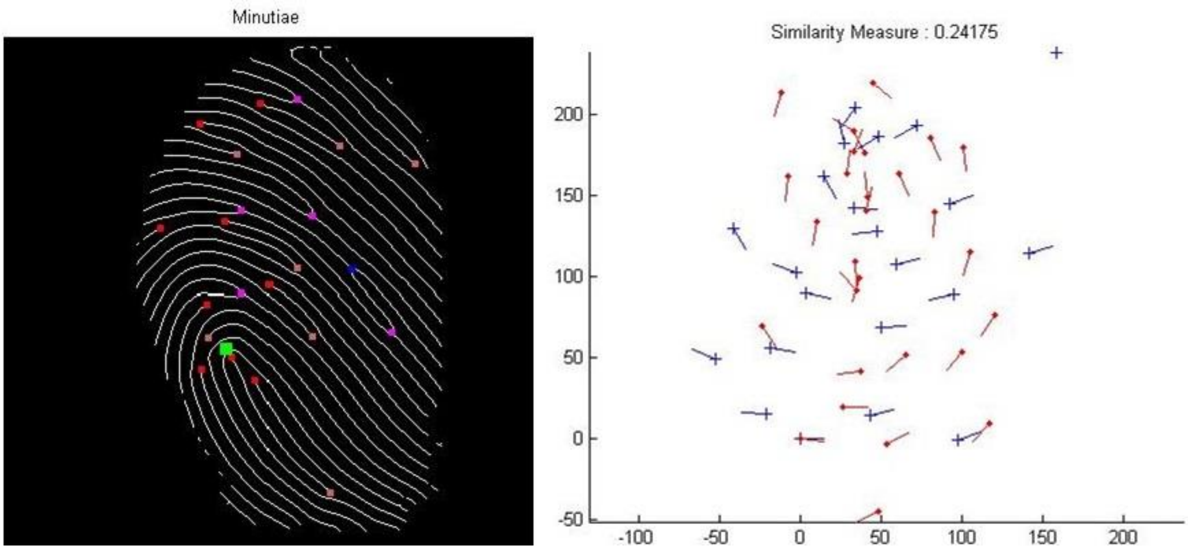
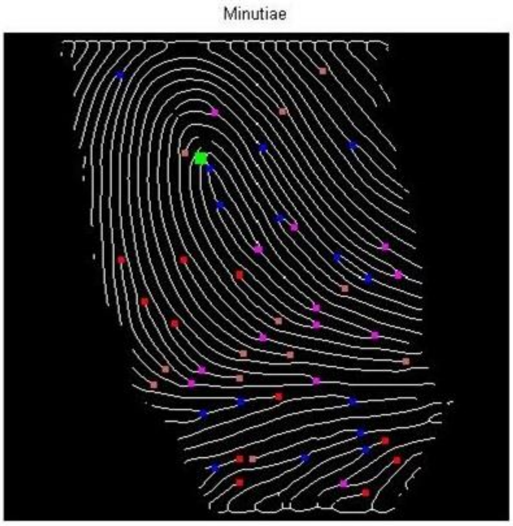


Fig 5.3 Result of (a) minutia of sample image (1) (b)similarity score sample image (1) and test image=0.24175

Fig 5.4 (a) sample image (2) (b) result of sample image(2)



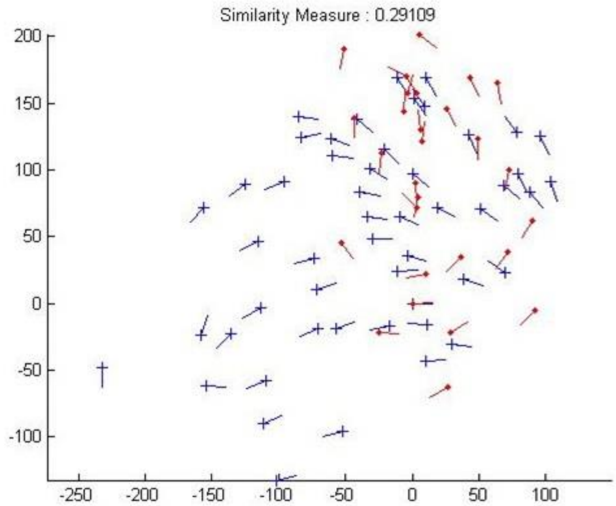


Fig 5.5 Result of (a) minutia of sample image (2) (b)similarity score sample image (2) and test image=0.29109

Fig 5.6 (a) sample image (3) (b) result of sample image(3)

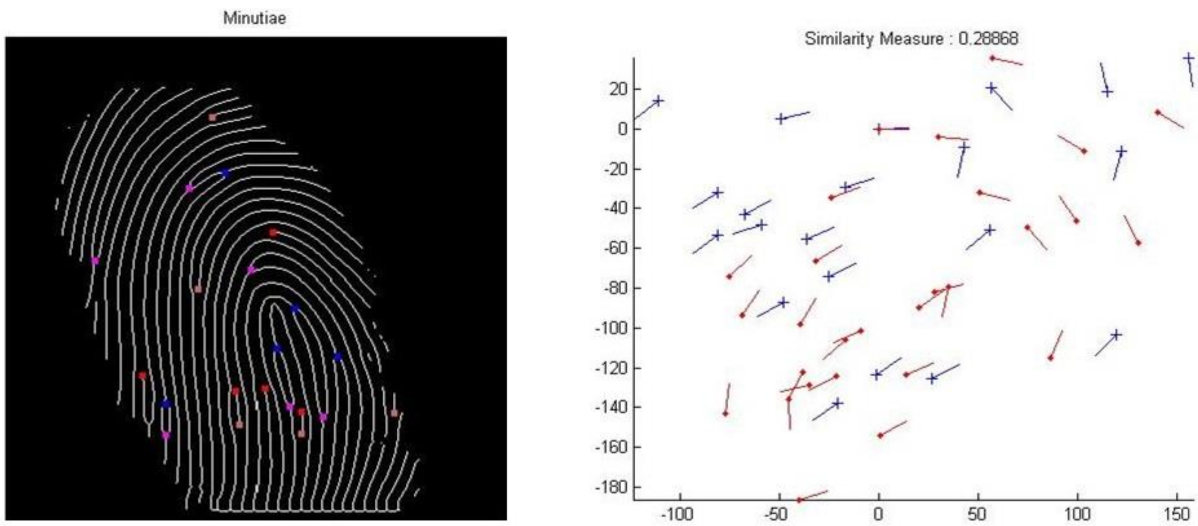
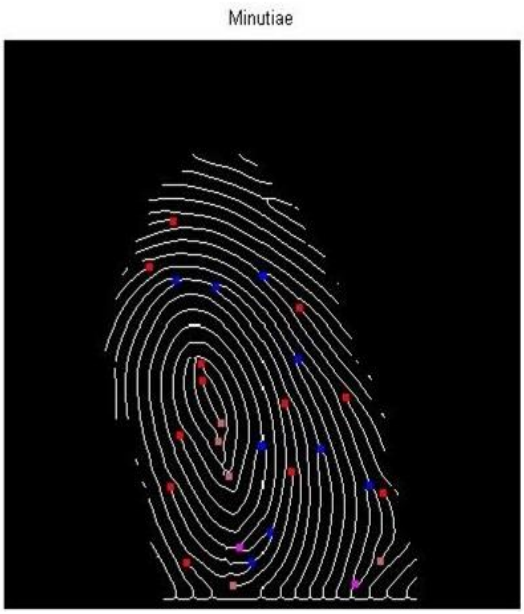


Fig 5.7 Result of (a) minutia of sample image (3) (b)similarity score sample image (3) and test image=0.28868

Fig 5.8 (a) sample image (4) (b) result of sample image(4)



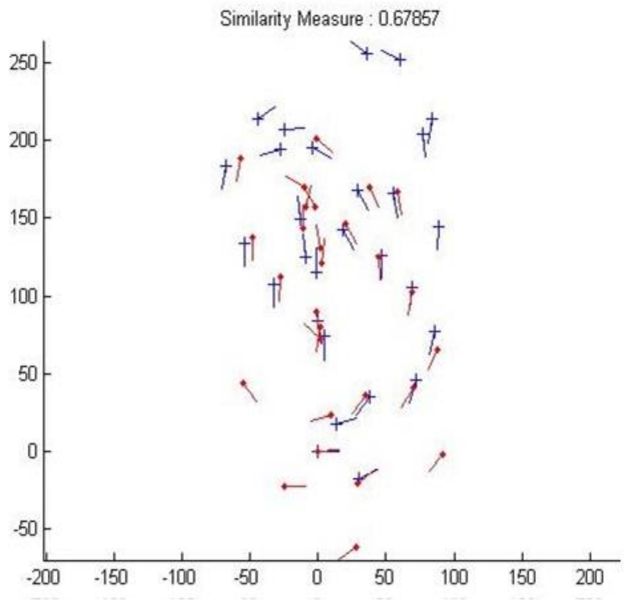


Fig 5.9 Result of (a) minutia of sample image (4) (b)similarity score sample image (4) and test image=0.67857

CHAPTER 5
CONCLUSION

CONCLUSION

5.1. Conclusion

In this paper, we had discussed about the result of the enhanced finger impression algorithm and verify the result with the raw sample. We also found that enhanced finger impression give us more accurate value in identification and verification of the sample fingerprint with the stored database finger impression images. We had modified many previous algorithm to get a better result.in case of enhancement we deal with block wise processing rather than pixel. For orientation purpose we divide the whole image into X×X and then estimated the orientation centered pixel. Wavelet transform is very productive to remove the unnatural noise and compression, so the further processing on the compressed image is much faster. The result in every stage show us the difference in enhanced image3 and real finger image. Final stage, thinning, give us the clear view about the ridge orientation, ridge ending and bifurcation.

Then, in next chapter we had discussed about the minutia extraction and verify it with the stored finger impression image in database. Hybrid descriptor is very effective in removing the unnatural minutia and the orientation descriptor improve the matching score. Gaussian weighing of the similarity function for registration improve the similarity score .δ- Neighborhood concept improve the accuracy for minutia pairing.

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