Authoritative Cropped Fingerprint Recognition using Termination and Bifurcation

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***Abstract* - This paper introduced a fingerprint matching using minutiae matching algorithm which generally used to two types of representation, that ridge ending (Termination), ridge Bifurcation. These proposed features are widely used in fingerprint matching, which mainly used to reduce compactness of minutiae points using cropping the original fingerprint images into two like horizontal cropped image and vertical cropped image based on their center point of whole image. These both horizontal and vertical cropped images has applied image enhancement, which improve their quality (Image binarization and Image thinning). Calculate the vector values for both cropped image and compare each and combine if common vector values are available then crop that common part. Detect the minutiae points (Termination and Bifurcation) for the common part image with false minutiae points. The false minutiae points were eradicated and apply image orientation using gradient based approaches with sobel filter. Hereafter received the accurate minutiae points from that fingerprint image, which compare with existing database (FVC 2002 DBI, DB2) results. This proposed minutiae matching algorithm has been evaluated with respect to above success rates.**

***Keywords* - Fingerprint, minutiae matching, Binarization, Termination. Image Cropping, Gradient based, Sobel filter**

I. INTRODUCTION

Fingerprint is a unique or distinctive pattern that presents unambiguous evidence of a specific person. The impression is formed by a pattern of ridges on the skin surface. Classification of fingerprint will help us to reduce fingerprint matching time for large database. Fingerprints are classified into following categories: Whorl, loop and Arch. (Fig-1)

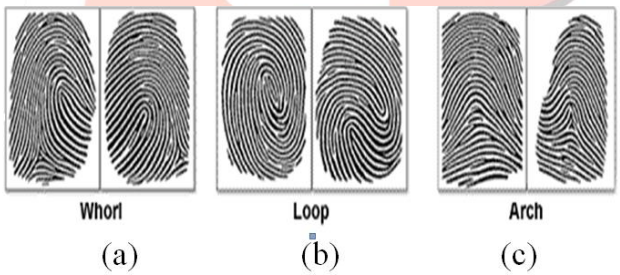


Fig.1 Fingerprint major Classification.(a) Whorl,(b) Loop, (c) Arch.

Fingerprint are graphical patterns of ridges and valleys on the surface of fingertips, mainly focused and widely used fingerprint feature as minutiae matching, which basically represent as the dot, short ridge, lake, spur, bridge, double bifurcation, trifurcation, ridge ending, opposed bifurcation, ridge crossing and bifurcation . (Fig-2) A minutiae based representation has more accurate, simplicity and more efficiency. Different methods were proposed based on minutiae match; first as a kind of local features, it is easy to extract various factors from the large database. Second to analysis of fingerprints with proposed mathematical model are independent and extended to pattern matching and utilized the ridge distance information. In last, many researchers proposed to use other features for fingerprint matching beside minutiae. [1] The minutiae are difficult to be extracted robustly due to various factors for intact image. Because image having lot of minutiae points, that difficult to identify accurately due to different directions, pressure, noise, poor quality image. The spurious minutiae will degrade the performance seriously. [3]

II. FINGERPRINT MATCHING TECHNIQUE

Fingerprint matching techniques emerge huge number of classifications. The main three common classifications are Correlation based, Pattern based and Minutiae based [1]

III. CORRELATION BASED RECOGNITION SYSTEM

The Fingerprints are aligned and computed the correlation for each pixel, however as the displacement and rotation are unknown it is necessary to apply the correlation for all possible alignments. The most common drawback of this method is computational complexity and less to tolerance. These have been proposed to compute the correlation locally instead of globally (e.g. Minutiae & Singularity) are reference (Stored) and query (Input) image.[21]

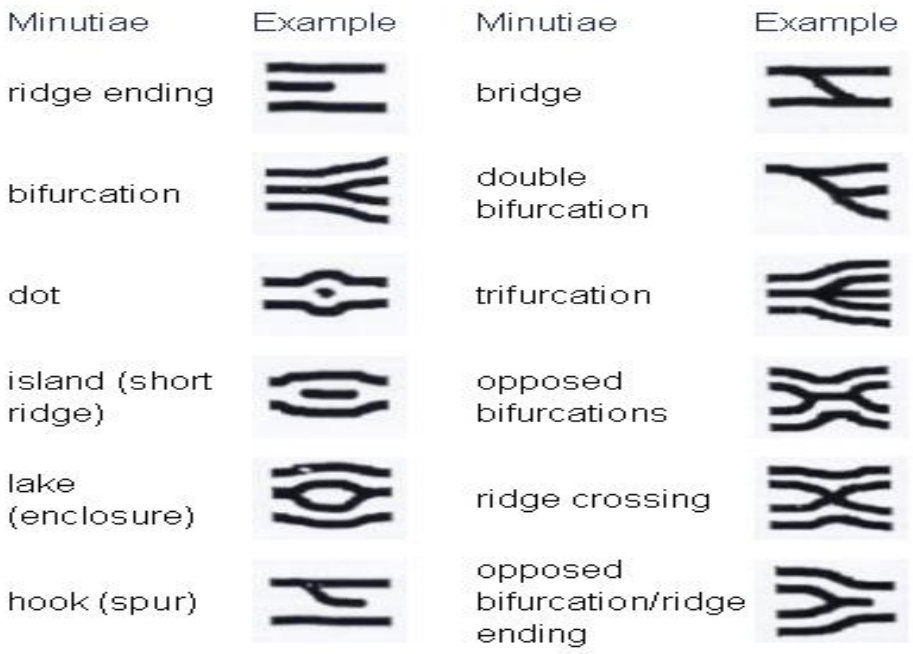


Fig.2 Minutiae point Classification

IV. PATTERN BASED FINGERPRINT

Pattern based algorithm compare the basic fingerprint patterns like as Arch, Whorl and loop between the reference and query image. This also requires the image to be aligned in the same orientation. The algorithm finds a central point. So the main drawback of this contains their type, size and orientation pattern within the aligned image. So we have implemented a Minutiae based fingerprint matching technique. This approach has been intensively studied and also backbone of the currently available fingerprint recognition.[2]

V. MINUTIAE BASED FINGERPRINT

The most popular method and widely used to match the fingerprints using extract minutiae points from two fingerprints and stored as a set of points in the two dimensional plane. Minutiae matching essentially consist of finding the alignment between the template and input minutiae sets, that result is maximum number of minutiae paring. [1]

VI. PROPOSED ALGORITHM

Minutiae based matching methods widely used to identify the person form large database. This method tries to align the minutiae of the input image (query image) and stored image (reference image) then find the number of matched minutiae for the whole image. After the alignment process, two minutiae points are consider in matching if the special distance and direction between them which smaller than given tolerance. In order to compute efficiently aligning information that has been proposed in this section, this method is crop the source fingerprint image as vertical and horizontal rectangular image based on their center point. The cropped image has been enhanced to improve the quality if the image is in less quality. Enhancement algorithm is to apply for Minutiae matching technique based on vector. Our proposed method computation works based on Row and Column. (Fig.3). Values should store in a database the query image also calculate same vector values and compare with reference image.

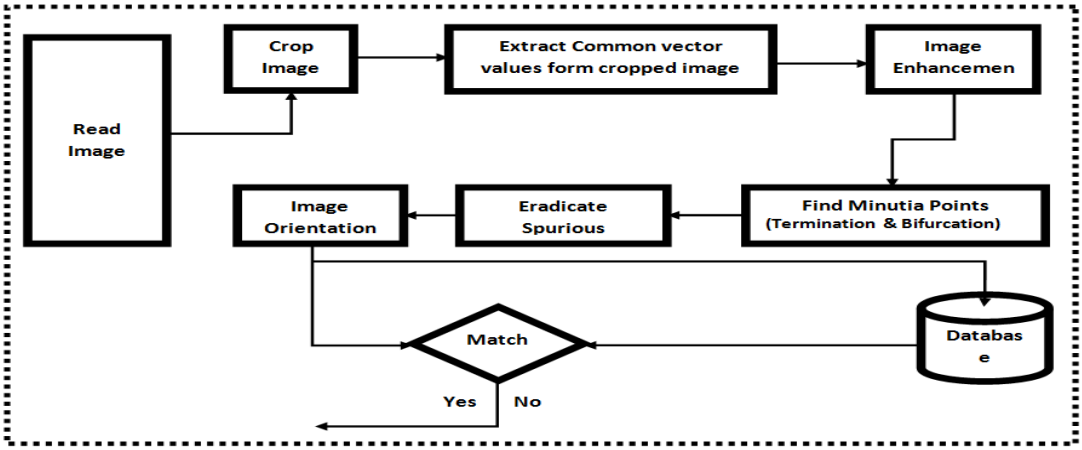


Fig.3 Overview of the project

VII. FEATURE EXTRACTION

A Fingerprint consists of two basic types of Minutiae, ridge ending and Bifurcation. (Fig.4)

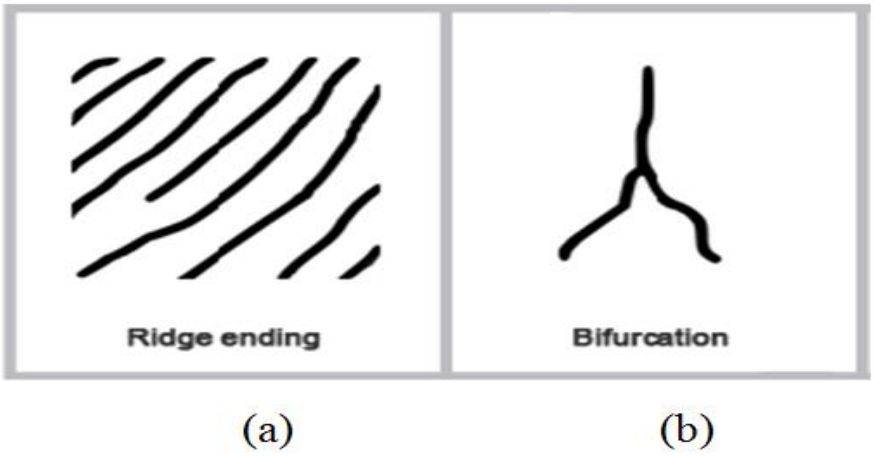


Fig.4. (a) Termination (b) Bifurcation

The Minutiae or their relative positions to each other are used for comparisons, that more accurate the process of extraction of minutiae, more reliable in entire automated fingerprint recognition system becomes.[2]

VIII. FINGERPRINT IMAGE READING

The Fingerprint image is loaded by using mat lab built in function 'imread'.

IX. RGB TO GRAY IMAGE

The original fingerprint image is in the RGB format. That image changed into gray scale image using mat lab built in function 'rgb2gray'.

X. CROP IMAGE AND COMBINE

The gray scale fingerprint image has been cropped based on their center point as vertical and horizontal rectangular image. Because the whole image has lot of minutiae points then eradicate false minutiae points for the same whole image. It takes more time to identify, so crop that image as rectangular in both vertical and horizontal based on center of image. (Fig.5).This process calculates vector values for both horizontal and vertical rectangular region. Such Row left, Row right, Row Center, Column top, Column bottom, Column Center.That minutiae vector values are store reference image to database which vector values are same and crop it. (Fig.6)

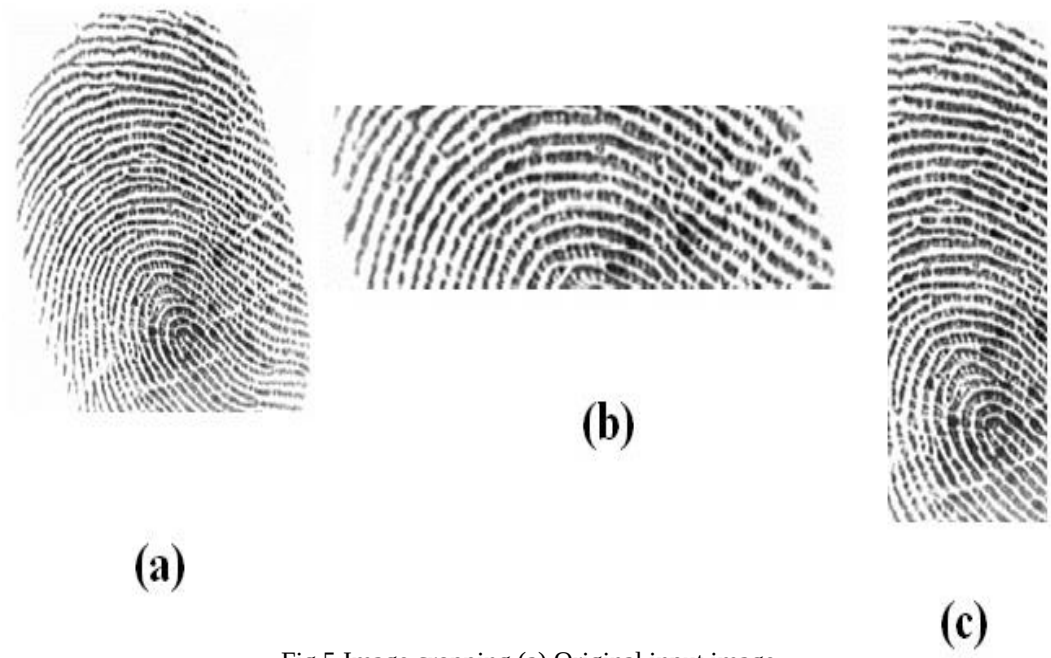


Fig.5 Image cropping (a) Original input image.
(b) Horizontal Cropping using center point.(c) Vertical Cropping using center point

Fig.6 Compare both cropped image and extract common part. (a) Comparision of both cropped image based on vector values. (b) Extract common part.

XI. IMAGE ENHANCEMENT

Obtained image have less quality or noisy as like as sensor error, lack of ink and over ink. The cropped image has to be enhanced. This will make it clear by improving perception or interpretability. Hence the accuracy of matching will be increased. The quality of image has been upgraded and contrast between ridges and valleys can be increased. So this process helps to keeping the fingerprint performance as more accuracy using Histogram equalization. The mat lab built in function is 'histeq'.

XII. BINARIZATION

The gray scale image has been converted in to Binary image. Gray scale image has 256 gray level (0 to 255) while the binary image consist of zero's and one's (0, 1) where zero is ridge and 1 is furrow (0 – Black, 1 – White). [21] The simplest ways to use image binarization to choose a threshold values are classify all pixels with values. If pixel values are above the threshold value which is white and all other pixel are black. The problem is how to select the threshold value, finding the threshold value as difficult. Therefore adaptive image binarization is needed where an optimal threshold. [1]

XIII. THINNING

Thinning process reduces the thickness of all line of fingerprint of single pixel. Once thinning process is completed no more pixels will be removal and noise or other singular points. The morphological function should use for the thinning process. The matlab built in function is 'bwmorph (BW,'thin'). [23]

XIV. TERMINATION AND BIFURCATION

This process extracting minutiae points based on number of one (1) value of every 3 X 3 matrix window. $L(x) - M(x) * [\sum_{I = 1 \text{ to } 9} M(i) - 1]$ Where L(x) denotes values of function at pixel x. M is the 3 X 3 Matrix. Algorithm for Finding Neighborhood pixels are. (Table.1 &Table.2) [23]

0	**0**	**1**
0	**1**	**0**
0	**0**	**0**

Table 1. Termination

0	**1**	**0**
0	**1**	**0**
1	**0**	**1**

Table 2. Bifurcation

- If the center is one (1) and has only one () value is neighbor then central pixel is a termination. If L(x) = 1, then it is a termination pixel. (Fig.7. (b))

- If the central is one (1) and has three (3) one value neighbors, the central pixel is bifurcation. If L(x) = 3, then it is a bifurcation pixel. (Fig.7. (b))

- If the central is 1 and has 2 one – value as neighbor, then central pixel is a usual pixel. If L(x) = 2, then it is a connected pixel

XV. SPURIOUS MINUTIAE REMOVAL

The earlier steps for minutiae detection does not discover absolutely true. The false ridge breaks due to insufficient amount of ink and ridge cross connections due to over inking and are not totally eradicated. The entire earlier step for minutiae detections are some artifacts which leads to spurious minutiae points. That spurious will eradicate and hold the original minutiae points for fingerprint image as following twelve types. These are Break, Spur, Merge, Triangle, Multiple breaks, Bridge, Break and Merge, Ladder, Lake, Island, Wrinkle and Dot. [15]

XVI. PROCEDURE TO ERADICATE SPURIOUS

1. If the distance between one bifurcation and one termination is less than Threshold value, then the two minutiae are same ridge is called as spur. So remove both termination and bifurcation ridge.

2. If the distance between two bifurcations is less than Threshold value, then they are same ridge. These are called as multiple breaks, Lake, Triangle and Ladder. So remove both bifurcation ridges

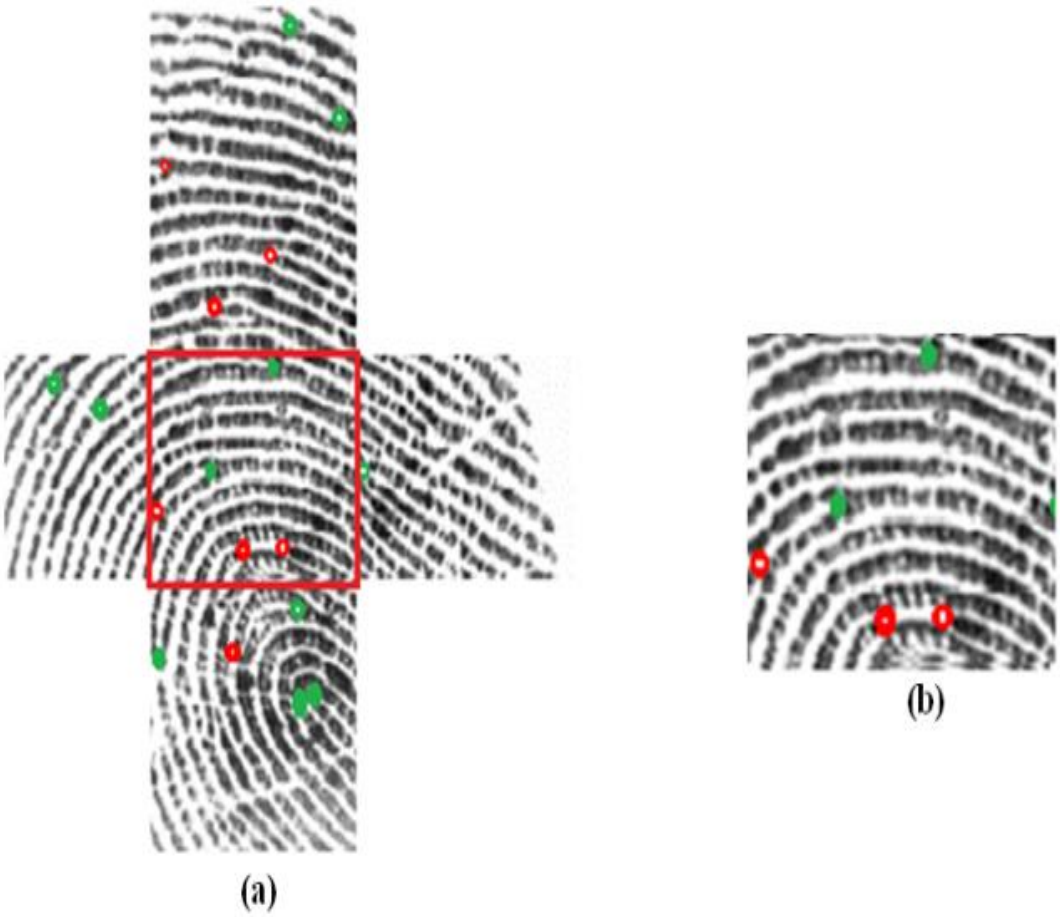


Fig.7 Identify Termination & Bifurcation. (a) Compare and Identify minutiae from both cropped image. (b) Crop the common image and identify minutiae points

3. If two terminations within a distance with threshold value and their directions are coincident with a small angle variation. They suffice the condition that no any other termination is located between two terminations. The false minutiae derived from broken ridge and are removed. These are called as Break, Island and Dot cases.

4. If two terminations are located in short ridge with less than Threshold value, then remove two terminations.

5. If a branch point has at least two neighboring branch point, which are each no further away than maximum distance threshold value and these branch points are closely connects on common line segments then remove the branch point. This is called as Wrinkle.

XVII. MINUTIAE ORIENTATION POINTS

ORIENTATION

The orientation applies for after completing image enhancement and other major steps during any other process (Segmentation). The orientation to be determining one is facing towards depends on their operation it may differ. This technique is used to get feature from any object know feature extraction. The great example for orientation is face detection, which identify eyes, nose, ears, eyebrows, etc.

MINUTIAE ORIENTATION TECHNIQUE

Orientation estimation technique is use to estimate direction flow of the minutiae present inside the image. The most popular orientation estimation techniques are

1. Gradient Based Approaches
2. Filter Bank Based Approaches

Above techniques can be used to extract information from images, which create from the original image using many of filters. Estimation field is an essential for a fingerprint recognition system. Gradient based method is a popular and sensitive to detect noise. This method uses to spatial and temporal partial derivatives that image flow at every position. The filter – bank based image approaches are more resistant to detect noise but they do not provide the accuracy because they have limited number of filters. Fingerprint orientation play vital roles in fingerprint enhancement, fingerprint recognition and restore poor quality to high quality fingerprint image. Fingerprint image contains minutiae points, trivial task to detect minutiae from image. Minutiae point detection can be performed by basic operation of edge detection. Actually gradient based approaches has finds the directional maxima of the gradient minutiae (edge strength) that apply threshold value. Threshold value is used to decide actual presence of an edge at image. The result obtained by sobel filter. Sobel operator used in matlab built in fuction fspecial ('sobel') which return 3 X 3 filter and horizontal gradient is gained by filter.

$$G_x = \text{filter2 (h,image)}$$

Finally the vertical gradient is achived by just transpose function

$$\text{Trans\_h} = \text{transpose (h)}$$

$$G_y = \text{filter2 (trans\_h, image)}$$

The output obtained by sobel filter. That utilize using mathematical operations are interacts with an angles. The result converted to arrow representation with the respective angles. [12]

XVIII. EXPERIMENTAL RESULT

The proposed fingerprint recognition approach has been evaluated on fingerprint images (388X374 pixels) acquired through a 500dpi optical scanner collection. to demonstrate the effective proposed minutiae extracting features which is more general. We choose the conventional minutiae based method, which extracts popular minutiae feature in additional to that cropping input image like vertical and horizontal strip based on center point of image. This proposed method has been increased accuracy, less consumption time, high tolerance and also used to calculate minutiae matching score.

For this excremental result, we used the database FVC2002 DB1, which contains 100 fingerprints from 25 fingers in different directions (with 4 impressions per finger). The verifier has been used for minutiae points to extraction and matching. This algorithm also proposed for image orientation extraction which reference point detection has been impact on accuracy and efficiency of our proposed system. We have to split input image as two that has vertical and horizontal striped image based on center point of image. Then calculate minutiae matching points from (Termination & Bifurcation) the above two striped image individually and vector points of both image has been stored in database. The two vector points were comparing and extract the common center part with correct minutiae points. (Fig.8). For example, consider vertical image and horizontal image. That has split manually like Column top, column Center, Column bottom, row left, row center, row right. These parts were compared and common part has been extracted, then find minutiae points from that extracted image. That reference image has to store in database. The same principles were applied to query image also and match with already stored reference image. Finally find the matching score, false acceptance rate (spurious). Causes of cropping the original image

1. It possible to read input image as any directions of fingerprint image
2. It possible to find all minutiae points from common parts (Vertical & Horizontal Image)
3. To enhance the image quality if input image is in poor quality

4. This process easy to count the minutiae points in small region. So we get the high tolerance of image
5. This process also eradicate the spurious points accurately because the region is small
6. This process produced good result that is very accuracy of minutiae points, less time to execute, high tolerance for error detection (spurious eradication).

XIX. PERFORMANCE EVALUATIONS

We used the database image FVC 2002 DB1 images. This contains 100 fingerprint images from 25 fingers with different direction (4 impressions per finger). Then calculate the performance based on the following metrics, accuracy rate, time for existing database (FVC 2002 DB1) images and real time images (scanned stamp impression). The both metrics has been calculated from existing result (FVC 2002 DB1). The following table has explained the performance comparison of existing result based on False Minutiae Rate (FMR), Actual Minutiae Rate (AMR) (Table.3 & Graph.1).

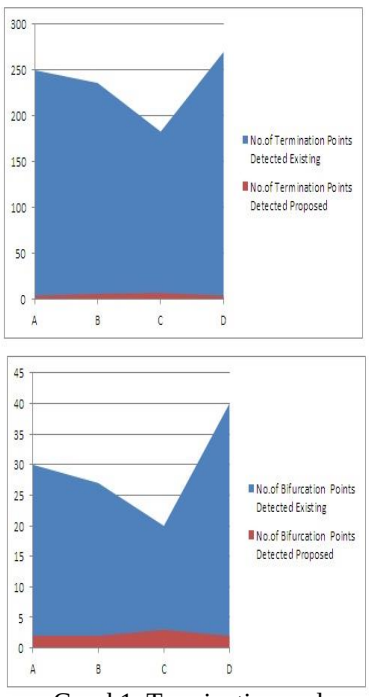
Next we examine real time scanned fingerprint (Table 4 & Graph 2) samples to evaluate with same principles that can be created for 100 fingerprints 25 set with different direction (4 impressions per finger). Those images were evaluated and stored in database. There is real time result (Experimental result) only no existing results. So we just compare with the above table experimental result. That helps to conclude this project work. These performances are given below.

XX. CONCLUSIONS

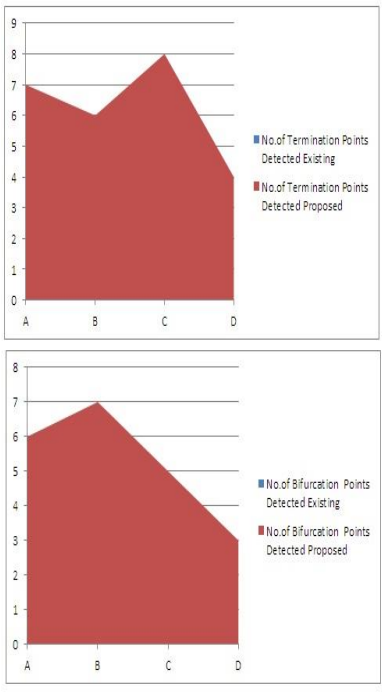
The biometrics is a wide area to do the research work; in this paper we present a framework for fingerprint that will help to produce the accurate detection of minutiae points and matching score form fingerprint image. Experimental results shows that our proposed method is better that conventional minutiae based method. We can also conclude that the model was produced the high accuracy, less time consumption and very good matching score. Recognition based on Minutiae matching algorithm with cropping the input image to two vertical and horizontal images based on center point and apply orientation map to output of the fingerprint image.

FVC 2002 DB1 Image Data set	No.of Termination Points Detected		No.of Bifurcation Points Detected	
	Existing	Proposed	Existing	Proposed
A	250	4	30	2
B	236	6	27	2
C	183	7	20	3
D	270	4	40	2

Real Time Image Data set	No.of Termination Points Detected		No.of Bifurcation Points Detected	
	Existing	Proposed	Existing	Proposed
A	NIL	7	NIL	6
B	NIL	6	NIL	7
C	NIL	8	NIL	5
D	NIL	4	NIL	3



Graph1. Termination and Bifurcation Count



Graph2. Termination and Bifurcation Count in Real Time

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