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Matching of Altered Fingerprint using Minutiae Technique

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Abstract- Fingerprint is the most widely used biometric technology among existing biometrics technology. Fingerprint recognition refers to the automated method of verifying a match between two human fingerprints. Fingerprint recognition is most reliable source of identification but still suffers from the problems such as fake fingerprint for conceal identity, altered fingerprints for masking one`s identity. Fingerprints can be altered by various ways such as cutting, burning, applying strong chemicals on fingertips, etc. Fingerprint image quality assessment software's cannot always detect altered fingerprints every time. Criminals are evading their identification from fingerprint recognition system by altering their fingers. This paper discusses the types of altered fingerprints and matching of altered fingerprint using minutiae matching technique. Our system produce a match count indicating the matching percentage of altered fingerprint with its unaltered mate.

Keywords- Biometrics, Fingerprint patterns, altered fingerprint, AFIS, minutiae.

I. INTRODUCTION

Biometrics is a method of recognizing a person based on physiological and behavioral characteristics such as face, fingerprints, hand geometry, handwriting, iris, palm print, voice. Among all biometric modality fingerprint is the most popular biometric identification technique. Fingerprints are unique even twins does not have same fingerprint patterns. A fingerprint contains many features as termination, bifurcation (fig-1), loops, island, whorls, core, delta but the most widely used feature of fingerprint is ridges and valleys. Ridges are the dark area and valleys are the white area on fingerprint.

Fig 1- A typical fingerprint with its features

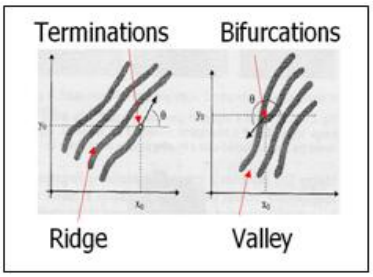

Fig 2 – typical termination and bifurcation.

A. *Altered fingerprints*

Now a day's many issues are arising in the fingerprint system security. Criminals are hiding their identification from systems using various measures such as fake fingerprint, altered fingerprints, etc. The main purpose of fingerprint alteration is to dodge identification using techniques such as abrading, cutting, burning fingers, performing plastic surgery, etc. Altered fingerprints are different from fake fingerprints. Fake fingerprints are facsimile of real fingers, these are used to adopt another person's identity. However altered fingers are the real fingers which are used to mask

B. *Types of Altered Fingerprint*

According to the changes made to the ridge patterns, fingerprint alterations may be categorized into three types as follows

Table 1. Types of altered fingerprints

Obliteration	Distortion	Imitation
Friction ridge patterns on the fingertips can be obliterated by abrading, cutting, burning, applying strong chemicals. Factors	Friction ridge patterns on the fingertips can be turned into unnatural ridge patterns by plastic surgery, in which portions of the skin are	In imitation a surgical procedure is performed in such a way that the altered fingerprints appear as a natural fingerprint ridge

such as skin diseases and side effect of cancer drug can also obliterate fingerprints.	removed from the finger and grafted back in different positions.	pattern.
		

II. BACKGROUND AND RELATED WORK

Minutiae are classified as ridge ending and bifurcations. Minutiae extraction starts with the thinning process J.Venkatesh et al, presented a fingerprint recognition method based on minutiae matching and thinning filter is used for thinning process [3]. Generally minutiae matching consist of two steps as minutiae extracting and minutiae matching. The performance of fingerprint matching is depend on the accuracy of minutiae extraction process. Crossing number method is used for extraction of minutiae [1]

A new algorithm for locating virtual core or centroid point in the fingerprint image is presented. The distance between the virtual core point and the minutiae points are calculated and it is considered as a random variable. Then statistical parameters are calculated and matching is done based on these parameters [2]. It is difficult to extract complete ridge structure automatically. Matching algorithm that uses both minutiae points and texture information. For extracting global and local features of image bank of Gabor filters is used. Matching is performed based on Euclidian distance of test and template fingerprint [4]. For minutiae extraction various preprocessing techniques used. Segmentation is done using morphological operation. Minutiae extraction is done using crossing number method and false minutiae are removed. Minutiae matching is done by aligning minutiae points in x- y co- ordinate system [5]

III. FINGERPRINT MATCHING SYSTEM

The process of fingerprint recognition is as follows

1. **Image acquisition**- the fingerprint image which is to be detected is feed to the system
2. **Preprocessing**- this is done for making image more clearer and removing noise from the image so that it would be easier to extract the features from the image.
3. **Feature extraction**- important features are extracted depending on the technique used for matching the fingerprint.
4. **Matching**- it is the final step of typical fingerprint recognition system. Gives the matched fingerprint if present.

Fig 3.Fingerprint matching system.

A. EXISTING SYSTEM

In existing fingerprint recognition system quality assessment algorithms are designed to examine if the image contains sufficient information for matching (say minutia or other global features of fingerprint). They have limited capability. Obliterated fingerprints can easily evade fingerprint quality assessment software's, depending on the area of damage. If the area is small these quality assessment software cannot detect the fingerprint is altered or not

B. PROPOSED SYSTEM FOR FINGERPRINT MATCHING

The existing system`s quality assessment software cannot detect the altered fingerprint and hence it cannot detect it as altered fingerprint if the altered areas is small. The proposed system overcomes this problem as this system matches the obliterated fingerprints if the altered region is small. It also gives the score of how much percent the area of fingerprint is altered.

C. MATHEMATICAL APPROACH FOR MINUTIAE MATCHING TECHNIQUE

Let T and Q be the feature vectors representing the minutiae points from template and query fingerprint respectively. Each element of these feature vector is a minutiae point which is having different attributes such as location, orientation, type, etc. the most common representation of minutiae is the triplet x, y, θ. Where x, y is the minutiae location and θ is the minutiae angle. Let the number of minutiae in T and Q are m and n respectively.

$$T = m1, m2, \ldots\ldots, mm, \quad mi = xi, yi, \theta i, \quad i = 1, .. m$$
$$Q = m'1, m'2, \ldots \quad .m'n, \quad m'j = x'j, y'j, \theta'j, \quad j = 1, \ldots n.$$

A minutiae mi in T and $m'j$ in Q are considered matching, if the following condition satisfies.

$$Sd(m'j, mi) = \sqrt{((x'j - xi)2 + (y'j - yi)2)} \leq r0 \qquad eq(1)$$

$$dd((m'j, mi) = min(\ |\ \theta'j - \theta i\ |, 360 - |\ \theta'j - \theta i\ |) \leq \theta 0 \qquad eq(2)$$

Here, $r0$ and $\theta 0$ are the parameter of the tolerance window which is required to compensate for errors in feature extraction and distortion.

The number or "matching" minutiae points can be maximized if the proper alignment between query and template fingerprints can be found.

$$Match\,(m''j, mi) = 1 \ \ if\ m''j\ \ and\ mi\ \ satisfies\ eq\ (1)\ and\ \ (2)$$
$$= 0\ otherwise$$

Where, $map\ (mi) = m''j$. Thus minutiae matching problem can be formulated as

$$Max \sum_{i=0}^{m} match\,(map(m'p(i)), mi)$$

Where p () is the minutiae correspondence function that determines the pairing between minutiae points in Q and T.

D. STEPS FOR FINGERPRINT MATCHING

1. Convert RGB image into gray scale

Gray scale image is easier for processing than RGB. The RGB image is converted into the gray scale image using following instruction in MATLAB

$$I = rgb2gray(RGB)$$

It converts tricolor image RGB into gray scale image I, it eliminated hue and saturation information and retains the luminance. Gray scale image is 8 bit image. Then this gray scale image is converted into binary image. We have applied local adaptive binarized method to convert gray scale image into binary.

2. Enhancement

Enhancement is done to improve the quality of fingerprint image. Quality of fingerprint affects the recognition rate. If the quality of fingerprint is high then recognition rate is better. We have used Gaussian low pass filter for enhancement as it takes less time.

$$h = fspecial\ ('Gaussian', hsize, sigma)$$
$$B = nlfilter\ (A, [m\ n], fun)$$

We have processed image pixel-by pixel, so we have applied nlfilter

3. Ridge flow estimation

Ridge flow shows the direction of ridges. In the altered fingerprint ridges are unfair where as in normal fingerprints the ridges are uniform. We have used gradient based approach to calculate the ridge flow. Gradient means slope or hike. Gradient gives information about how the image is changing and in what direction it is changing. The local orientation at some pixel (i,j) can be calculated as

$$Vx(i,j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} 2\ Gx(u,v)Gy(u,v) \qquad (3)$$

$$Vy(i,j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=i-\frac{w}{2}}^{j+\frac{w}{2}} (Gx2(u,v) - Gy(u,v)) \qquad (4)$$

$$\theta(i,j) = 0.5tan'(Vx(i,j)/\ Vy(i,j)) \qquad (5)$$

Where $\theta(i,j)$ is the least square estimation of local orientation at center pixel (i,j)

4. Region of Interest

Only critical area in the fingerprint is extracted so that accurate results can be obtained. The region of interest is the area with which we are dealing.it is the bound region which is obtained after substation of closed area from the opened area. The morphological operation is done using following functions.

$$Bwmorph(x, "close")$$
$$Bwmorph(y, "open")$$

5. Thinning

Thinning is the process of making the pixel of fingerprint image one pixel wide.it does not change the orientation and location of minutiae. It is applied for efficient extraction of minutiae. We have performed thinning used following morphological operation in MATLAB.

$$BW2 = bwmorph\,(BW, thin)$$

6. Minutiae Extraction

We have used Crossing Number (CN) method for minutiae extraction. In this method minute points are determined by scanning the local neighborhood of each pixel using 3×3 window.CN is defined as half the sum of the differences between pairs of neighboring pixels as pi and $pi + 1$. A minutiae point is determined as either termination or bifurcation depending on the crossing number value which is obtained after scanning the local neighborhood of each pixel. CN value is calculated as

$$CN = 0.5 \sum_{i=1}^{8} (pi - pi + 1),\ \ p9 = p1 \qquad eq\ (6)$$

Following table shows CN values and corresponding property

Table 1- CN value and corresponding property

CN value	Property
0	Isolated point
1	**Ridge ending**
2	Normal ridge pixel
3	**Bifurcation point**
4	Crossing point

7. Minutiae Matching

The extracted minutiae are counted using elastic match algorithm and stored the .mat file. Comparison is made between the query fingerprint and every fingerprint stored in database if the matching score is greater than the predefined threshold then the two fingerprint are said to be of same person. The matching score of these two fingerprints is calculated by

$$Score = 100 \times Total\ number\ of\ minutiae\ in\ test\ fingerprint - total\ number\ of\ minutiae\ of\ template\ fingerprint$$

If the match score is above the predefined threshold then the fingerprints are said to be matched.

E. PROPOSED ALGORITHM

1. Convert the inputted RGB fingerprint image into gray scale image. Using the instruction

$$I = rgb2gray(RGB)$$

Then convert this gray scale image into binary image.

2. After converting the image into gray scale then enhancement is performed. Enhancement makes the image clearer so that features in the fingerprint image are clearly visible. We have used nlfiler because we are processing image pixel by pixel.

$$B = nlfilter\ (A,[m\ n],fun)$$

3. The whole image is divided into 16×16 block and evaluation of the orientation of the fingerprint is carried orientation field is estimated using gradient based method.
4. After orientation of the fingerprint is carried out then the image is smoothed by applying Gaussian low pass filter.

$$h = fspecial\ ('Gaussian', hsize, sigma)$$

5. To compute the region of interest (ROI), it is helpful because only he region which is critical is extracted and rest of the part is eliminated so that accuracy of the result gets increased.

6. Next step is minutiae extraction. For minutiae extraction thinning is done first. Thinning is nothing but making fingerprint image one pixel wide. It is done using morphological operation in MATLAB using the instruction as

$$BW2 = bwmorph\,(BW, thin)$$

7. After thinning minutiae are extracted using the crossing number method. Crossing number calculated

$$CN = 0.5 \sum_{i=1}^{8} (pi - pi + 1),\ \ p9 = p1$$

8. Once the minutiae are extracted then they are counted using elastic match algorithm and are stored in the .mat file.
9. Test fingerprints minutiae are compared with every fingerprint`s minutiae stored in the database.
10. If the match score is maximum then it is said that two fingerprint are matched and the matching score is displayed.

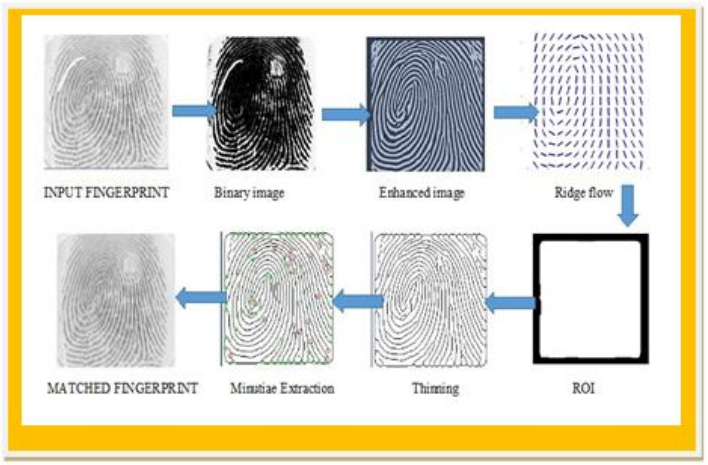

Fig 4- Process of Altered Fingerprint Matching

IV. EXPERIMENTAL ANALYSIS AND RESULTS

Due to lack of public domain database consisting of altered fingerprints. We have created altered fingerprints database. We have captured the original fingerprints using high definition camera (500 dpi) and simulated the altered fingerprints. Simulated four alterations (s1, s2, s3, s4) of each of these ten fingerprint images. The altered fingerprints are simulated in such a way that it will result in obliteration. These original fingerprints and corresponding altered fingerprints are stored in the database. The minutiae values of the original fingerprints are extracted using crossing number algorithm and they are count using elastic match algorithm. Then these minutiae values are stored in the. Mat file of MATLAB. Each inputted altered fingerprint is matched with the entire fingerprint in the database. We have defined threshold value 70%. A matching is declared as successful if the minutiae score of the altered fingerprint is equal to or above the predetermined threshold value. Following table gives the Matching rate of individual person in percentage. The fingerprint image is given from our synthetically altered fingerprint database.

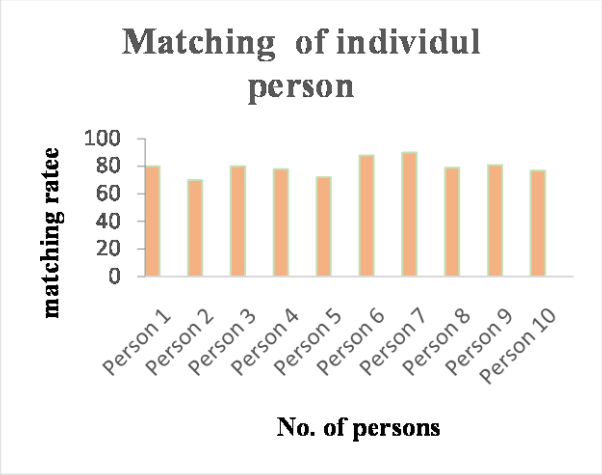

Fig 4 - Graph showing percentage of matching.

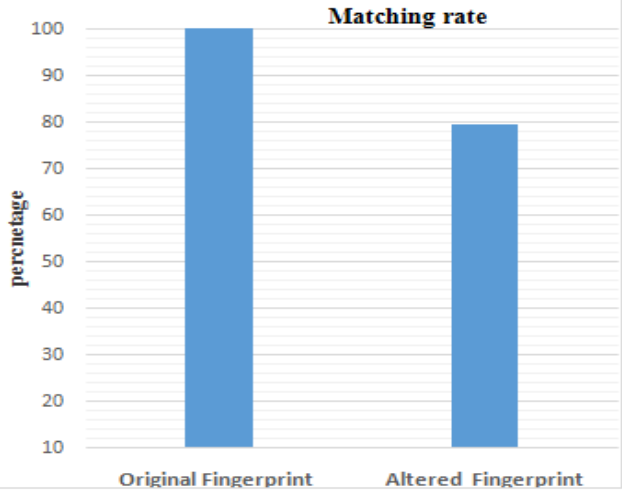

Fig 4- Graph showing average matching rate of altered Fingerprint and normal fingerprint

Table- 3 Individual Matching Rate

Name of the person	Average of % matching of individual person
Person 1	80
Person 2	70
Person 3	80
Person 4	78
Person 5	72
Person 6	88
Person 7	90
Person 8	79
Person 9	81
Person 10	77

Table-4 Average Matching rate of altered and original fingerprint.

Type of fingerprint	Number of fingerprint samples	Average Matching Rate in %
Original fingerprint	10	100
Altered Fingerprint	40	79.5

V. CONCLUSION

In this paper we discuss the minutiae matching technique to match the altered fingerprint with its original fingerprint. Minutiae based matching techniques are most widely used technique for fingerprint matching among existing technique as it is backbone of Automated Fingerprint matching System(AFIS). Depending on the fingerprint alteration area, the matching performance is calculated. The existing altered fingerprint matching techniques works only when the altered area is large enough and Detects only the fingerprint is altered or not. If the altered area is small then it does not consider it as altered fingerprint. Proposed system overcomes this problem it matches even though alteration area is small. It also acknowledges how much area is altered.

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