FINGERPRINT & HAND-PRINT RECOGNITITON SYSTEM

(USING MATLAB)

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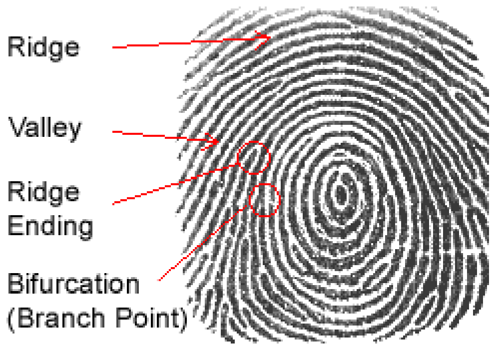
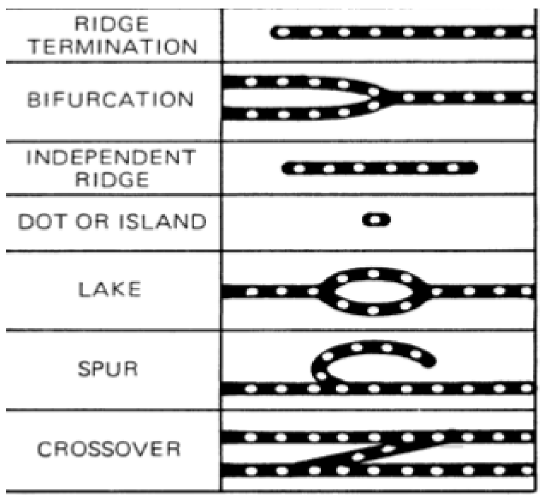
***Abstract*— A Biometric device is a security identification and authentication device. Such devices use automated methods of verifying or recognizing the identity of a living person based on a physiological or behavioral characteristics. Biometrics today play an important role in person identification for verification and unique identity. It is believed that fingerprint and handprint is unique for each person. This paper discusses about a fingerprint and handprint matching system based on Minutiae. Human fingerprints and handprints are rich in details called minutiae, which can be used as identification marks for verification. Fingerprints and handprints are a unique and reliable biometric characteristic with high usability. Fingerprint and handprint based recognition system is a promising method to recognize an individual based on properties of fingerprint and handprint image. It is rich in its features: principal lines, wrinkles, ridges, singular points and minutiae points. The main idea of this paper is to develop an efficient system for fingerprint or handprint matching through extracting and matching minutiae. To achieve good results preprocessing in form of image enhancement and binarization is first applied on fingerprints and handprints before they are evaluated. Many methods like Image enhancement, Thinning etc. have been combined to build a minutia extractor and a minutia matcher. Minutia-marking with false minutiae removal methods are also used further in the process. An alignment-based elastic matching algorithm has been developed for minutia matching. Thus by obtaining the level of match between the given fingerprint/handprint and the fingerprint/handprint in database the person can be identified.**

I. INTRODUCTION

It is a widely believed fact that each human being has a unique fingerprint and handprint. Though it has not been scientifically proved this assumption has been used for decades for identifying people uniquely. A Fingerprint is actually the pattern of ridges and valleys on the fingertip. Ridges and valleys are features of a fingerprint as shown in the figure below. Fingerprints and handprints are thus defined by the uniqueness of the local ridge characteristics(various relationships between valleys and ridges). Automatic and reliable extraction of minutiae from fingerprint images is a critical step in fingerprint and handprint matching. The quality of input fingerprint images plays a crucial role in the performance of automatic identification and verification process. For good quality minutiae extraction in fingerprints, preprocessing is done in form of image enhancement and binarization. Various methods have been adopted to build a minutia extractor and a minutia matcher. Minutia-marking with false minutiae removal methods are also used in the process to remove unnecessary information and save disk space while storing and also reduce run time while matching. An alignment-based elastic matching algorithm has also been developed for minutia matching. This algorithm is capable of finding the correspondences between input minutia pattern and the stored template minutia pattern without resorting to exhaustive search. Thus by using such effective techniques fingerprint and handprint recognition is done in real time.



The various types of minutiae are also shown below which are mainly used for identification.Using only ridge bifurications and ridge endings are enough to get a high level of accuracy which will also reduce overall complexity.



II. DESIGN OF THE SYSTEM

The minutiae extractor matching system is done in three stages.

- Pre processing
  1. Image Enhancement
  2. Image Binarization
  3. Image Segmentation
- Minutia Extraction
  1. Thinning
  2. Minutiae detection
- Post Processing
  1. Removal of false minutiae

PREPROCESSING

A. IMAGE ENHANCEMENT STAGE

The image needs to be enhanced before proceeding to match and identify as lower quality images will lead to errors.

A few enhancement methods are used, for increasing the contrast between ridges and valleys and for connecting the false broken points of ridges due to insufficient amount of ink, which are very useful for keep a higher accuracy to fingerprint recognition.

- **Histogram Equalization**: expands the pixel value distribution of an image so as to increase the perceptional information.
- **Fast Fourier Transform:** image is divided into small processing blocks (32 by 32 pixels) and perform fft according to the formula

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \times \exp\left\{-j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\}$$

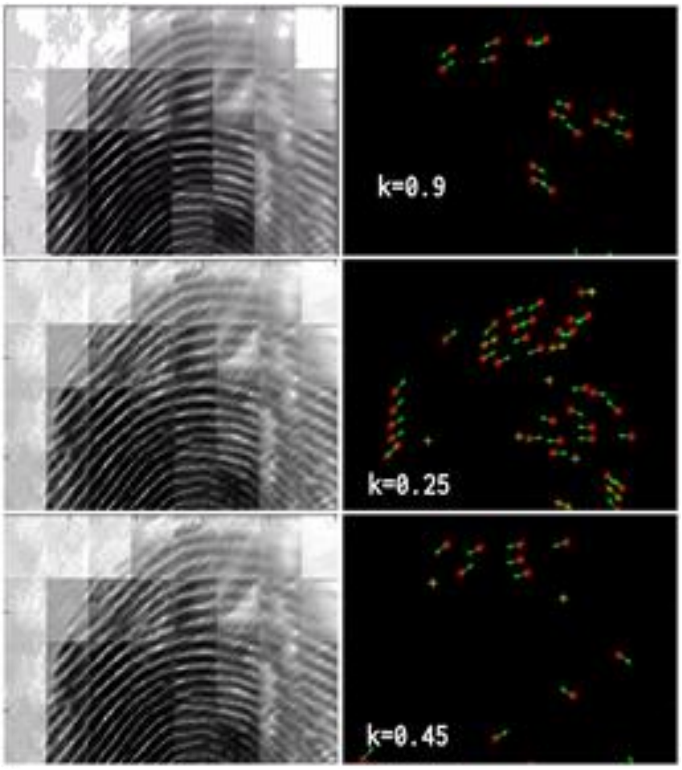
for u,v = 0, 1, 2, ..., 31. To enhance a specific block by its dominant frequencies, we multiply the FFT of the block by its magnitude (abs(F(u,v)) = |F(u,v)|) a set of times.
We get the enhanced block according to :

$$g(x,y) = F^{-1}\left\{F(u,v) \times |F(u,v)|^{K}\right\} \qquad (2)$$

where $F^{-1}(F(u,v))$ is computed using:

$$f(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v) \times \exp\left\{j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\} \qquad (3)$$

where x,y=0,1……,31. The k in formula (2) is an experimentally determined constant, which we choose k=0.45 because exactly at that value real minutia are marked with maximum accuracy. A higher "k" value improves the appearance of the ridges, filling up small holes in ridges, it can result in false joining of ridges. Thus a bifurcation might become a termination. Fig. 3 shows fft and real minutia marks for different k values.



B. IMAGE BINARIZATION

In this step the grey image (256 level image) is converted into binary image (2 level image) that gives the same information. Typically, an object pixel is given a value of “1” while a background pixel is given a value of “0”.

A locally adaptive binarization method is performed to binarize the image. In this method, the image is divided into blocks (16 x 16), and the mean intensity value is calculated for each block, then each pixel is turned into 1 if its intensity value is larger than the mean intensity value of the current block to block to which the pixel belongs.

C. IMAGE SEGMENTATION

Usually, only a Region of Interest is useful to be recognized for each fingerprint image. The image area without effective ridges is first discarded.

To extract the ROI, a two-step method is used. The first step is block direction estimation and direction variety check, while the second is done using some Morphological methods.

1. **Block direction estimation**

gradient values along x direction (g_x) and y-direction (g_y) for each pixel of the block (16X16) are calculated using two sobel filters. For each block, it uses the following formula to get the Least Square approximation of the block

$$\tan 2ß = 2 \sum \sum (gx^*gy)/\sum \sum (gx^2-gy^2)$$

direction.

Taking g_x as cosine and g_y sine value tangent value of

$$\tan 2\theta = 2\sin\theta \cos\theta /(\cos^2\theta - \sin^2\theta)$$

After finishing with the estimation of each block direction, those blocks without significant information (ridges) are discarded based on the following formula:

$$E = \{2 \sum \sum (gx^*gy)+ \sum \sum (gx^2-gy^2)\}/ W^*W^*\sum \sum (gx^2+gy^2)$$

For each block, if its certainty level (E) is below a threshold, then the block is regarded as a background block which gives a block direction estimation map assuming each image has only one fingerprint.

2. ROI extraction by Morphological operation

Two Morphological operations called 'OPEN' and 'CLOSE' are adopted. The 'OPEN' operation can expand images and remove peaks introduced by background noise. The 'CLOSE' operation can shrink images and eliminate small cavities.

MINUTIAE EXTRACTION

A .THINNING

Ridge thinning stage is to elimination the redundant pixels of ridges till the ridges are just one pixel wide. An iterative, parallel thinning algorithm is used. In each scan of the full fingerprint image, the algorithm marks down redundant pixels in each small image window (3 x 3) and finally removes all those marked pixels after several scans. The thinned ridge map is then filtered by other Morphological operations to remove some H breaks, isolated points and spikes. In this step, any single points, whether they are single-point ridges or single point breaks in a ridge are eliminated and considered processing noise.

B. MINUTIAE DETECTION

In this step the concept of Crossing number is used. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-valued neighbor, then the central pixel is a ridge ending. If Cn(i) = 1 then it's a ridge end and if Cn(i) = 3 it's a ridge bifurcation point.

Also the average inter-ridge width D is estimated at this stage. The average inter-ridge width refers to the average distance between two neighboring ridges. The way to approximation the D value is simple. Scan a row of the thinned ridge and sum up all pixels in the row whose values are one. Then divide the row length by the above summation to get an inter-ridge width. For more accuracy, such kind of row scan is performed upon several other row and column scans are also conducted, finally all the inter-ridge widths are averaged to get the D.

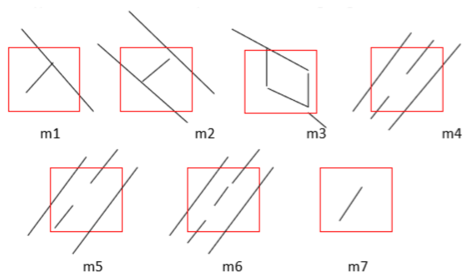
Together with the minutia marking, all thinned ridges in the fingerprint image are labeled with a unique ID for further operation.

POST-PROCESSING

1) REMOVAL OF FALSE MINUTIAE

The earlier stages themselves occasionally introduce some artifacts which later lead to spurious minutia. These false minutiae will significantly affect the accuracy of matching if they are simply regarded as genuine minutiae. So some mechanisms of removing false minutia are essential to keep the fingerprint verification system effective.

Seven types of false minutia are specified in following diagram:



The procedure for the removal of false minutia consists of the following steps:

1. If the distance between one bifurcation and one termination is less than D and the two minutiae are in the same ridge (m1). Remove both of them.

2. If the distance between two bifurcations is less than D and they are in the same ridge, remove the two bifurcations (m2 & m3).
3. If the terminations are within a distance D and their directions are coincident with a small angle variation. And they suffice the condition that no any other termination is located between the two terminations. Then the two terminations are regarded as false minutiae derived from a broken ridge and are removed (m4, m5 & m6).
4. If two terminations are located in a short ridge with length less than D, remove the two terminations (m7).

MINUTIAE MATCH

This step determines if the given two set of minutia of two handprint/fingerprint images are from the same hand/finger or not.

It includes two consecutive stages:

1. Alignment stage
2. Match stage

1. ALIGNMENT STAGE

Given two fingerprint images to be matched, choose any one minutia from each image; calculate the similarity of the two ridges associated with the two referenced minutia points. If the similarity is largely than a threshold, transform each set of minutia to a new coordination system whose origin is at the reference point and whose x-axis is coincident with the direction of the referenced point.

2. MATCH STAGE

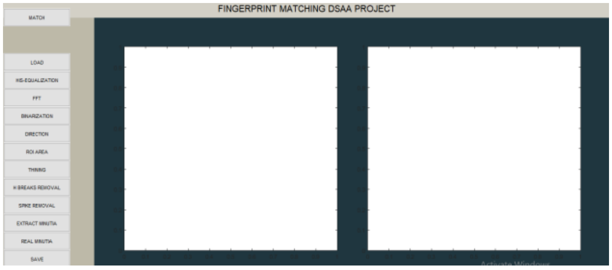
After we get two set of transformed minutia points, we use the elastic match algorithms to count the matched minutia pairs by assuming two minutia having nearly the same position and direction are identical.

RESULTS STAGE

The database consists of four kinds of images.

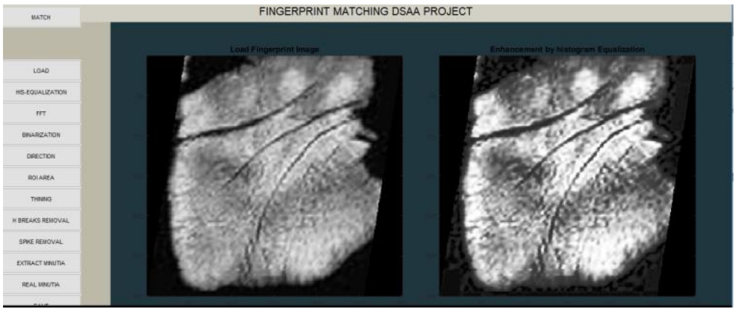
1. Database of fingerprints collected from internet.
2. Manually collected fingerprints.
3. Database of handprints collected from internet.
4. Manually collected handprints.

Now, the images from the database are processed and are stored, which will be used in matching stage.

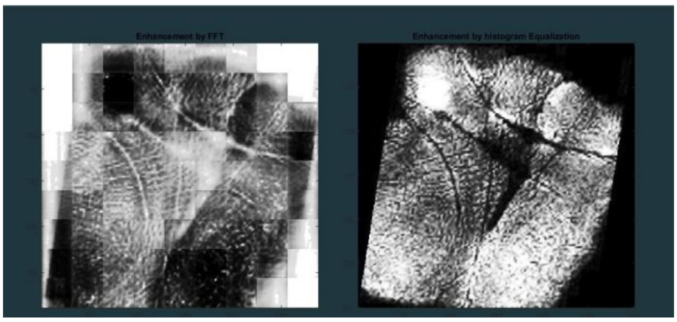


The following is the illustration for manually collected handprints.

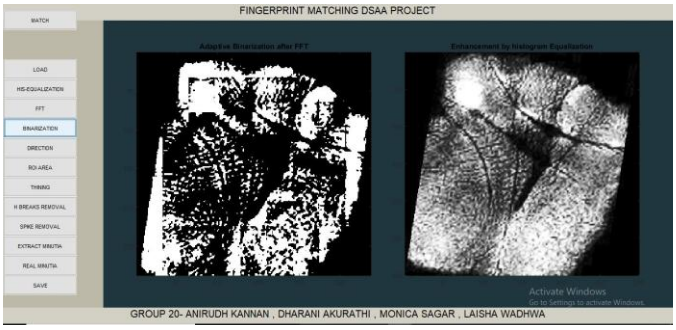
Step 1: Handprint Image is loaded from database and histogram equalization is applied.



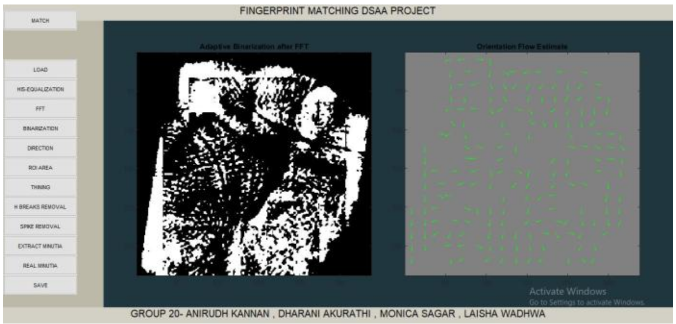
Step 2: Fourier transform, The image gets enhanced in this stage.



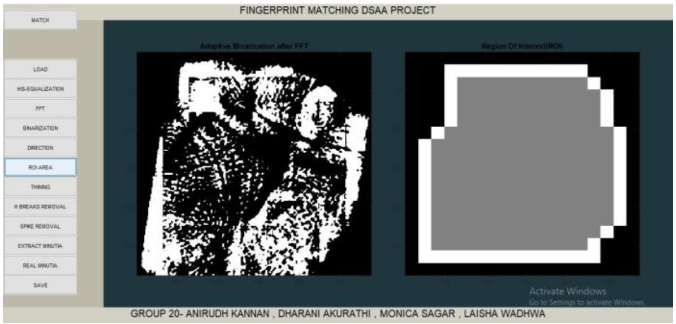
Step 3: Grey image is converted into binary image (2 level image)



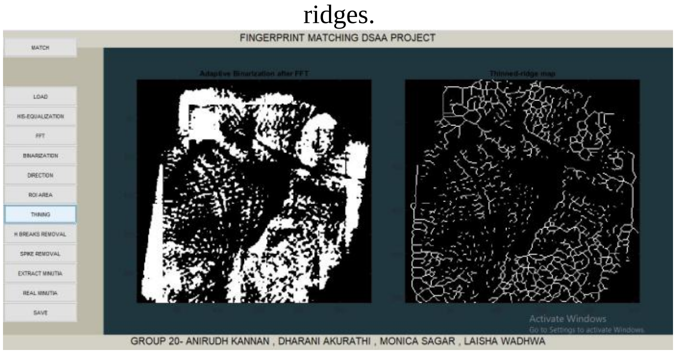
Step 4: Estimation of block direction for each block of the fingerprint image.



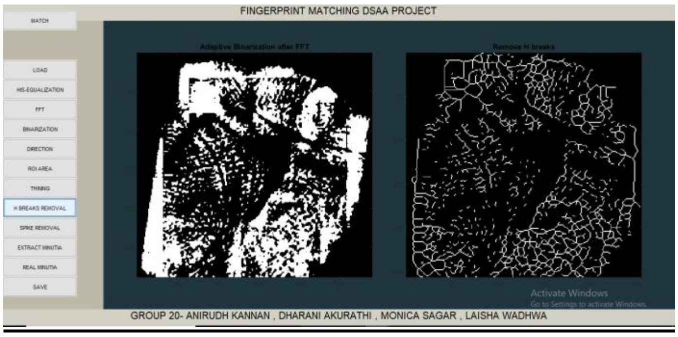
Step 5: Marking the region of interest for further process.



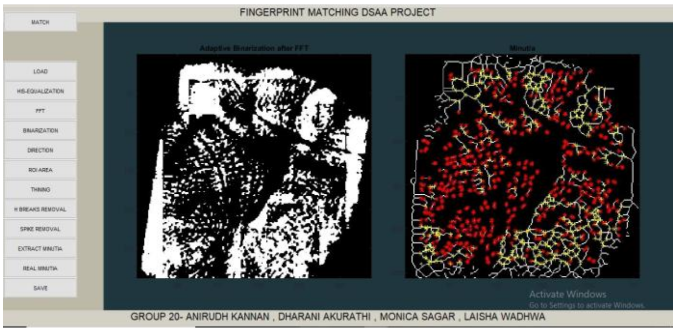
Step 6: Ridge Thinning to eliminate the redundant pixels of ridges.



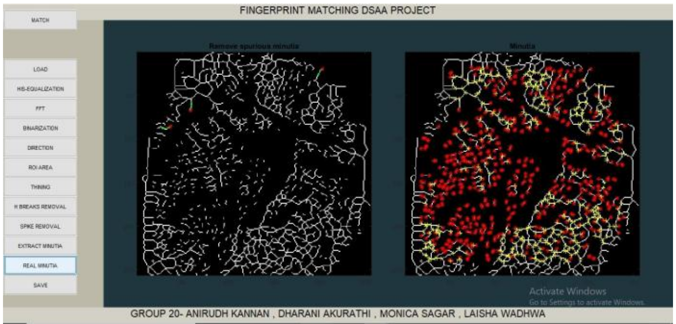
Step 7: H breaks are removed and spike removal is done.



Step 8: Ridge endings and ridge bifurcations are marked.

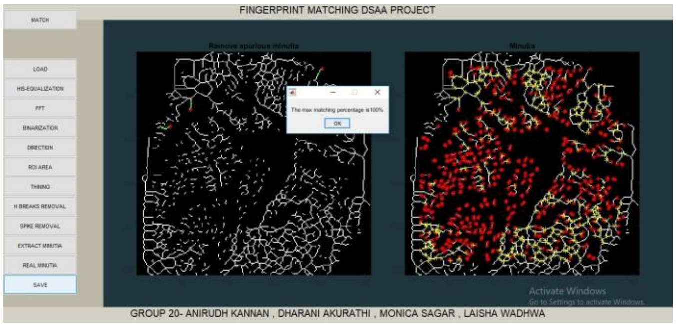


Step 9: Removing false minutiae which may give wrong output.



Step 9: The image is saved in .dat format so that it won't lose any information and is used matching stage.

Step 10: Matching, select two images from database which are preprocessed and are saved in .dat format. The images are loaded and matched. Now the result is percentage of matching. If the match percentage is greater than 75% then it considered as a match. (The percentage of match is the threshold set by the user which depends on the level of accuracy required. If required more accuracy required threshold can be set as 85 percent. To get a very high level of accuracy both fingerprint and handprint can be matched.)



CONCLUSION

- Our project reduces time complexity and saves memory space as we are getting rid of false minutiae and only storing the real ones. The testing database has scanned fingerprints using ink. The former dataset contains noise in the images. So, the goal of the project is to design a system which gives best results for even worst conditions. The dataset can be made of better quality if fingerprint is given as input using high end scanners.
- The project can be improved further in terms of efficiency and accuracy by improving the hardware. This method can also be adopted in other electronic devices to develop secure systems to identify inviduals uniquely.

Acknowledgment

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REFERENCES

[1] Irfan Ahmad1, Zahoor Jan2, Inayat Ali Shah3, Jamil Ahmad,-- HAND RECOGNITION USING PALM AND HAND GEOMETRY FEATURES

[2] S. Modi, A. Mohan, B. Senjaya, and S. Elliott, ―Fingerprint recognition performance evaluation for mobile id applications,‖ IEEE, 2010

[3] B. Bhanu, X. Tan, Learned templates for feature extraction in fingerprint images, Proceedings of the IEEE Conference on Computer Vision and Pettern recognition, vol.2, 2001, pp. 591-596.

[4] X. Luo, J. Tian, Y. Wu, "A Minutiae Matching Algorithm in Fingerprint Verification", Pattern Recognition, vol. 4, 2000, pp 833 - 836.

[5] B.Bhanu, S. Lee, Genetic Learning for Adaptive Image Segmentation, Kluwer Academic Publishing, Dordrecht, 1994

[6] L.C. Jain, U. Halici, I. Hayashi, S. B. Lee, S. Tsutsui, Intelligent Biometric Techniques in Fingerprint and Face Recognition, United States of America:CRC Press LLC, 1999.