Minutiae-based Fingerprint Matching

Nikhil S Hubballi

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INTRODUCTION

- Here, It's tried to match different fingerprints based on the minutiae features found in a fingerprint
- Two cases are considered in matching
  1. One to One matching
  2. One to Many matching

INTRODUCTION

- In One to One Matching, two sample fingerprint images are taken and they are compared for using the similarity measures based on the extracted features which are minutiae point
- This process is mainly to find if two given fingerprints are of the same person
- One area where this can be helpful is Crime Investigations
- In One to Many Matching, a sample fingerprint is taken and is compared with all the other fingerprints present in the database. Based on the similarity measure, it's found out if the sample fingerprint is of the same person as in the database
- This process is helpful in finding if a certain fingerprint is present in the database
- This can be helpful in attendance management, in authorising someone into the system etc

PROBLEM DEFINITION

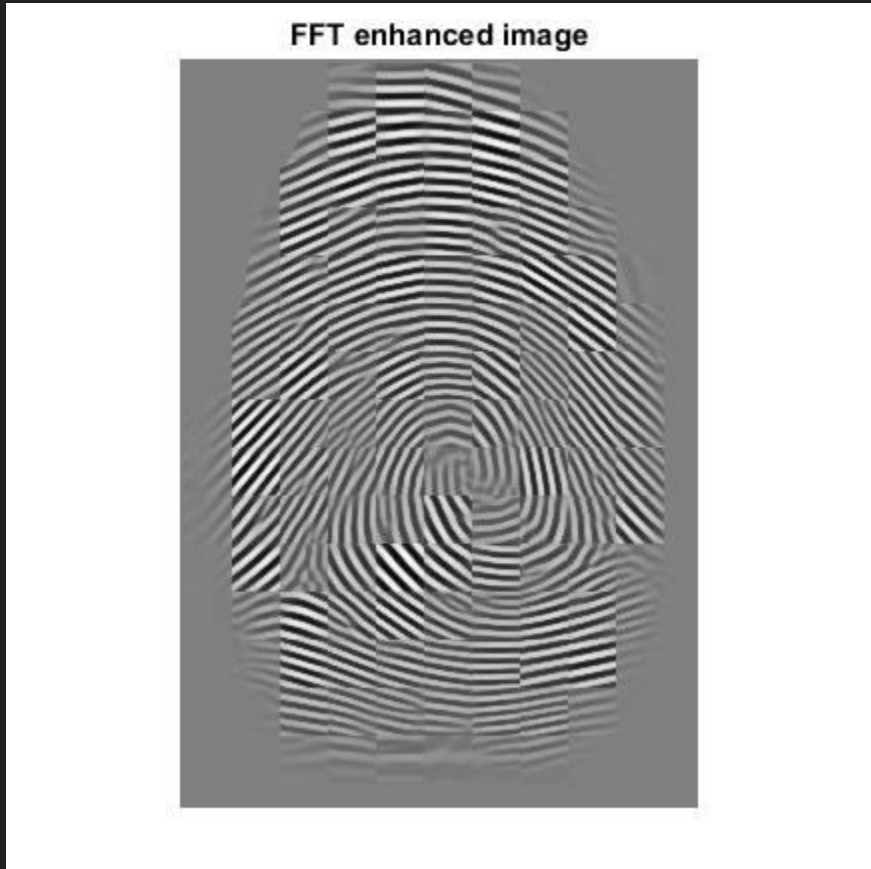
What, why and how?

- A fingerprint is defined by the uniqueness of the local ridge characteristics and their relationships
- Minutiae points are these local ridge characteristics that occur either at a ridge ending or a ridge bifurcation
- Automatic minutiae detection becomes a difficult task in low quality fingerprint images where noise and contrast deficiency result in pixel configurations similar to that of minutiae
- This is an important aspect that has been taken into consideration in this presentation for extraction of the minutiae with a minimum error in a particular location
- The proposed method uses improving alternatives for the image enhancement process, leading consequently to an increase of the reliability in the minutiae extraction task

Pre-Processing

Image Enhancement

- Before we proceed to feature extraction, we need to enhance image so that noise is removed, and is clearer for further operations
- As part of this, first FFT enhancing is done
- We divide the image into small processing blocks and perform the Fourier transform
- The enhanced image after FFT has the improvements to connect some falsely broken points on ridges and to remove some false connections between ridges



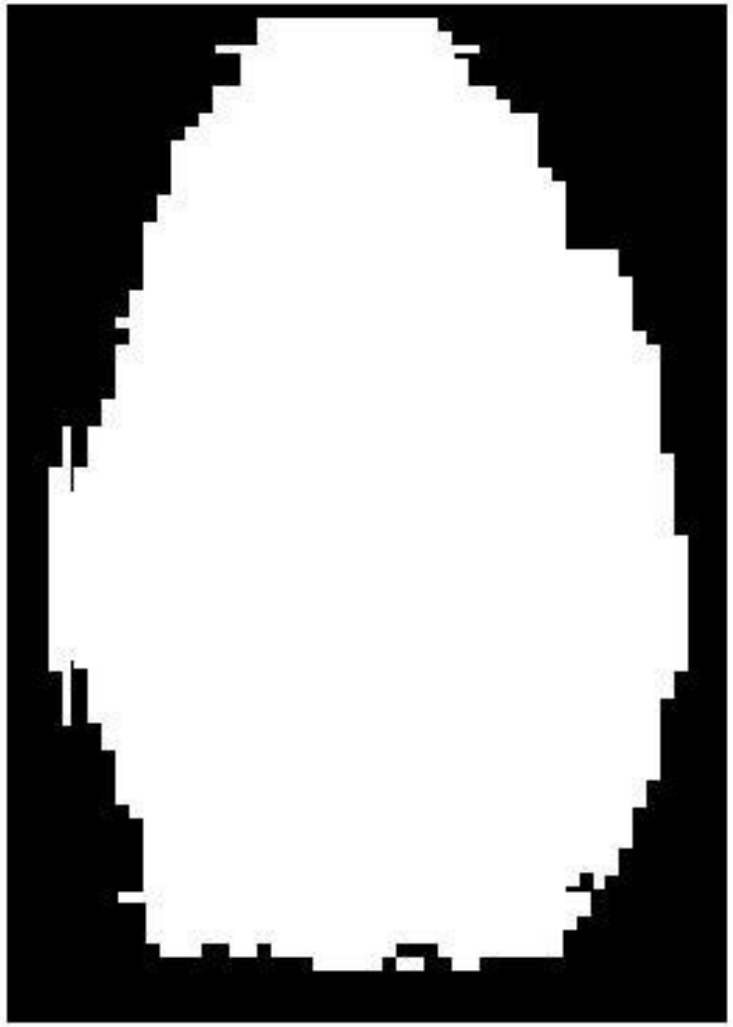
- After this, ridge segmentation is done where it identifies ridge-like regions of a fingerprint image. Also normalises the intensity value of the image

- Ridge orientation is done to estimate the local orientation of the ridges in a fingerprint
- Then local ridge frequency across a fingerprint image is estimated
- Then by applying ridge filter, we enhance a fingerprint image using oriented filters
- After this ridge filter application, we get a binary image

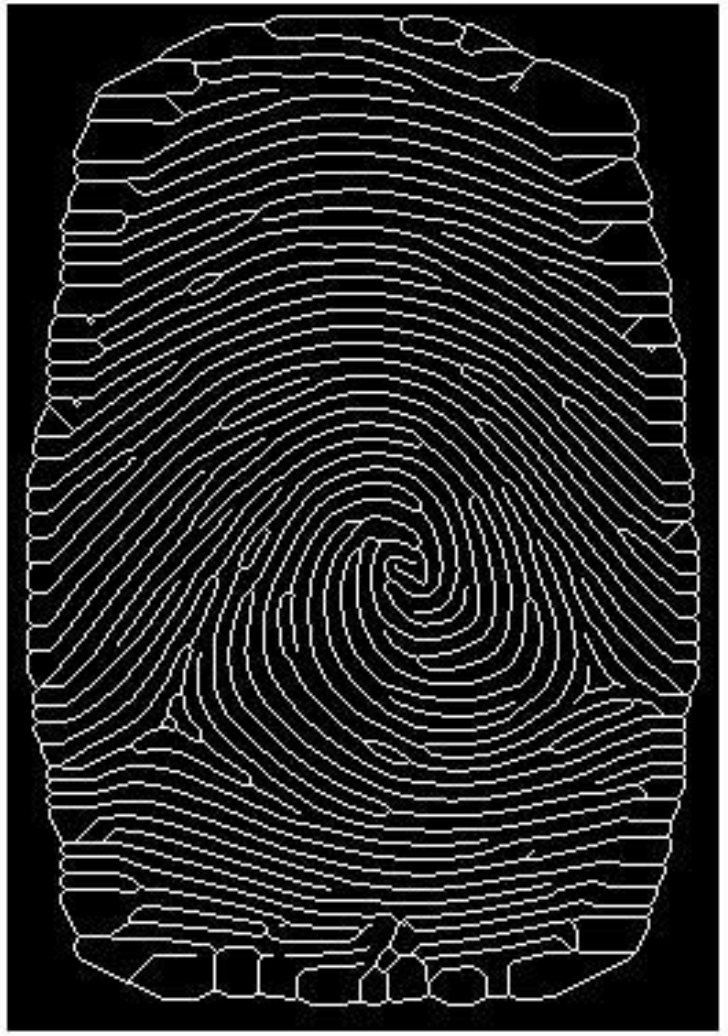
Binary Image

- Now, the image area without effective ridges is discarded since it only holds background information and probably noise
- Then the bound of the remaining effective area is sketched out since the minutiae in the bound region are confusing with those false minutiae that are generated when the ridges are out of the sensor
- So we need Region of Interest to undertake further operations
- We have two methods to do this. One is block direction estimation and the other is using some morphological methods
- Here, the morphological method is used
- After this the image is thinned so that all the ridges have just one pixel value in width

MASK image



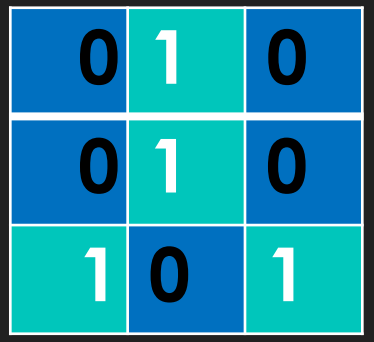
thinned image



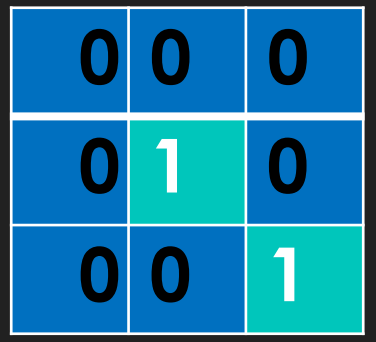
Minutiae Extraction

Features in the fingerprint image

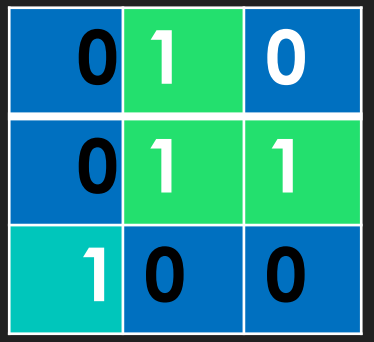
- The concept of Crossing Number (CN) is used for extracting minutiae
- In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch
- If the central pixel is 1 and has only 1 one-value neighbour, then the central pixel is a ridge ending
- for a pixel P, if Cn(P) = = 1 it's a ridge end and if Cn(P) = = 3 it's a ridge bifurcation point
- In the third image, a branch is counted thrice



Bifurcation



Termination

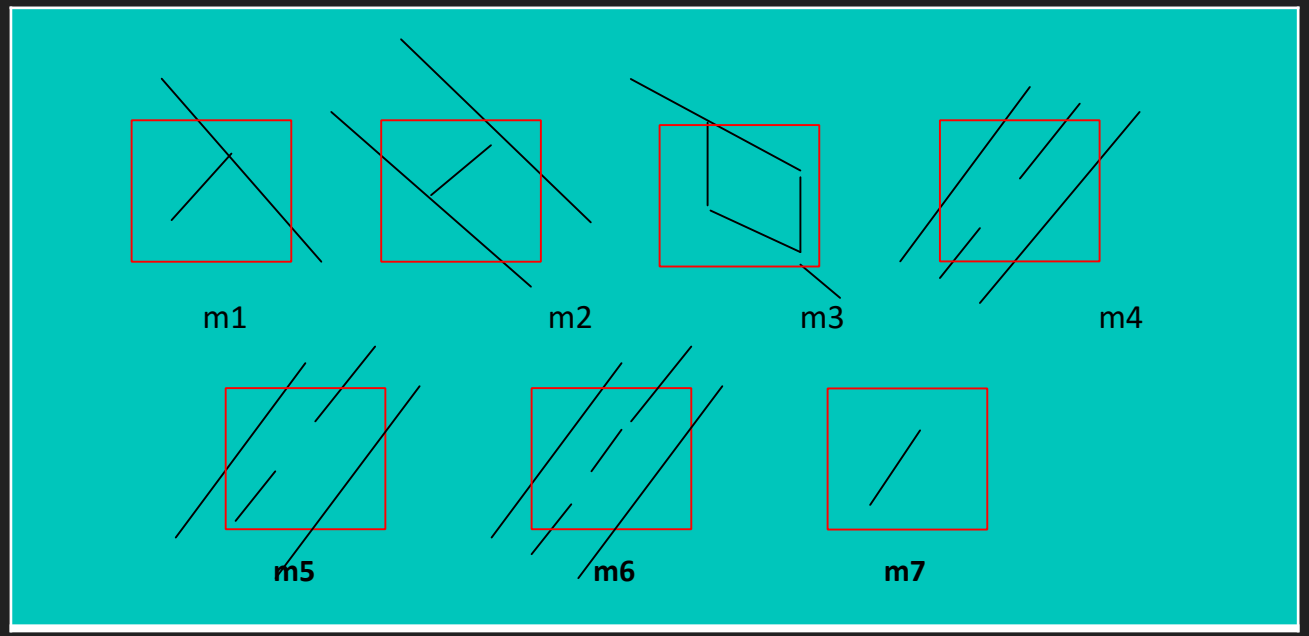


Triple counting branch

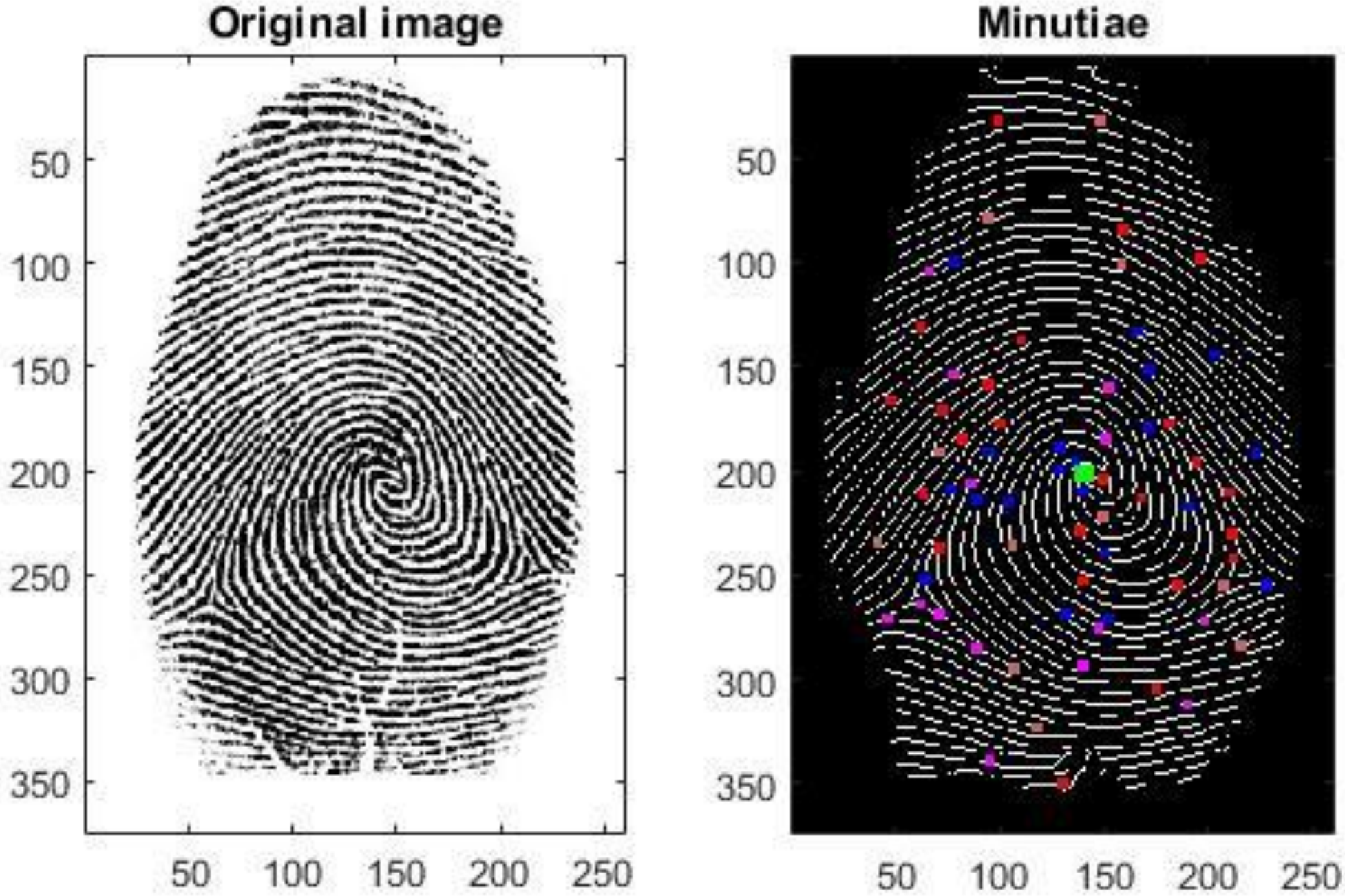
Minutiae Post-Processing

Removing false minutiae

- False ridge breaks due to insufficient amount of ink and ridge cross connections due to over inking are not totally eliminated
- These false minutiae will significantly affect the accuracy of matching if they are simply regarded as genuine minutiae
- To keep the fingerprint verification system effective, removing of false minutia is essential
- Some types of false minutiae are given in diagram



- The procedure for the removal of false minutia consists of the following steps:
- If the distance between one bifurcation and one termination is less than D and the two minutiae are in the same ridge (m1 case). Remove both of them. Where D is the average inter-ridge width representing the average distance between two parallel neighbouring ridges.
- If the distance between two bifurcations is less than D and they are in the same ridge, remove the two bifurcations. (m2, m3 cases)
- If two 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. (Cases m4,m5 & m6).
- If two terminations are located in a short ridge with length less than D, remove the two terminations (m7).


Original image
50
100
150
200
250
300
350
50
100
150
200
250
Minutiae
50
100
150
200
250
300
350
50
100
150
200
250

Minutiae Matching

Final fingerprint matching process

- First both the images are transformed such that they have same coordinates using following equation,

$$\begin{pmatrix} xi\_new \\ yi\_new \\ \theta i\_new \end{pmatrix} = TM * \begin{bmatrix} (xi - x) \\ (yi - y) \\ (\theta i - \theta) \end{bmatrix}$$

Where,

$$TM = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

- After this, using one image as the reference, the other image is rotated such that it becomes easy for finding similarity measure
- By placing a bounding box around each template minutia, If the minutia to be matched is within the rectangle box and the direction difference between them is very small, then the two minutiae are regarded as a matched minutia pair, here threshold for distance is 15 and threshold for theta(angle) is 14.
- Each time a minutia point satisfy this criteria, score is increased by 1
- This goes on until the whole image is covered and final score is noted.

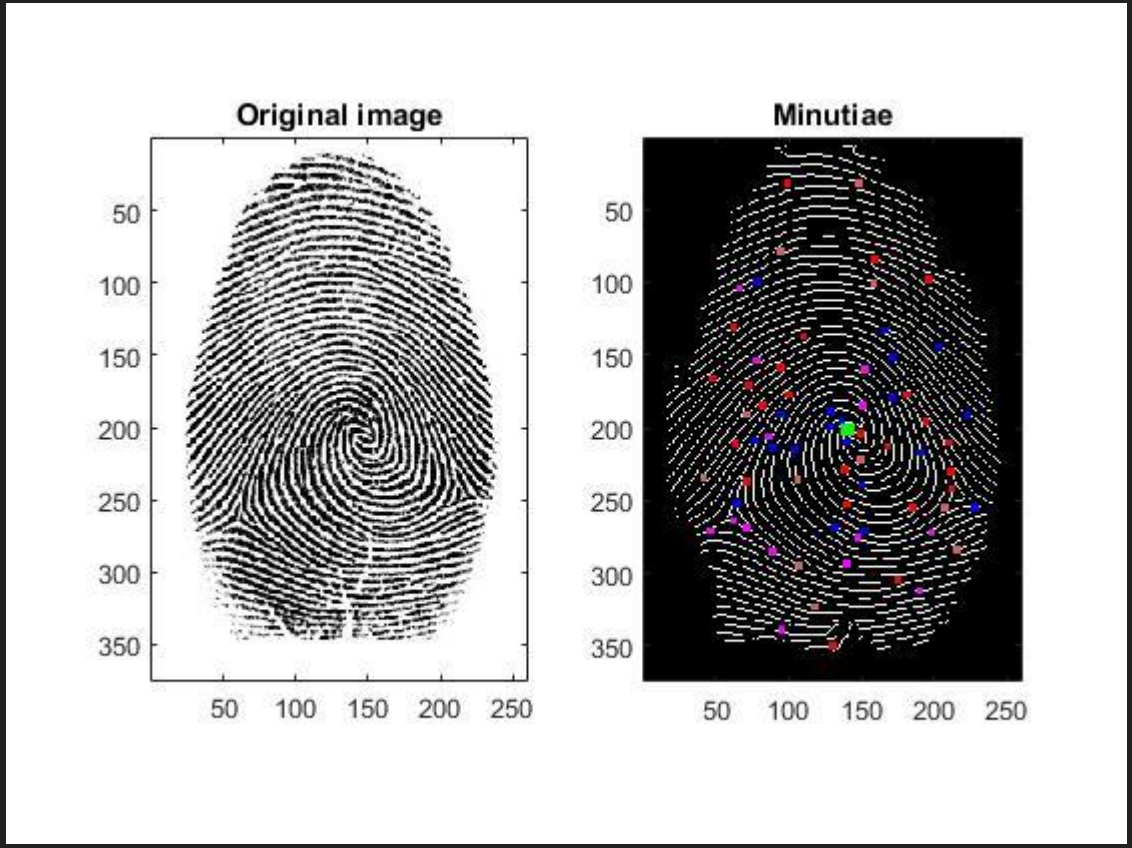
- Using this score, we find similarity measure from the formula,

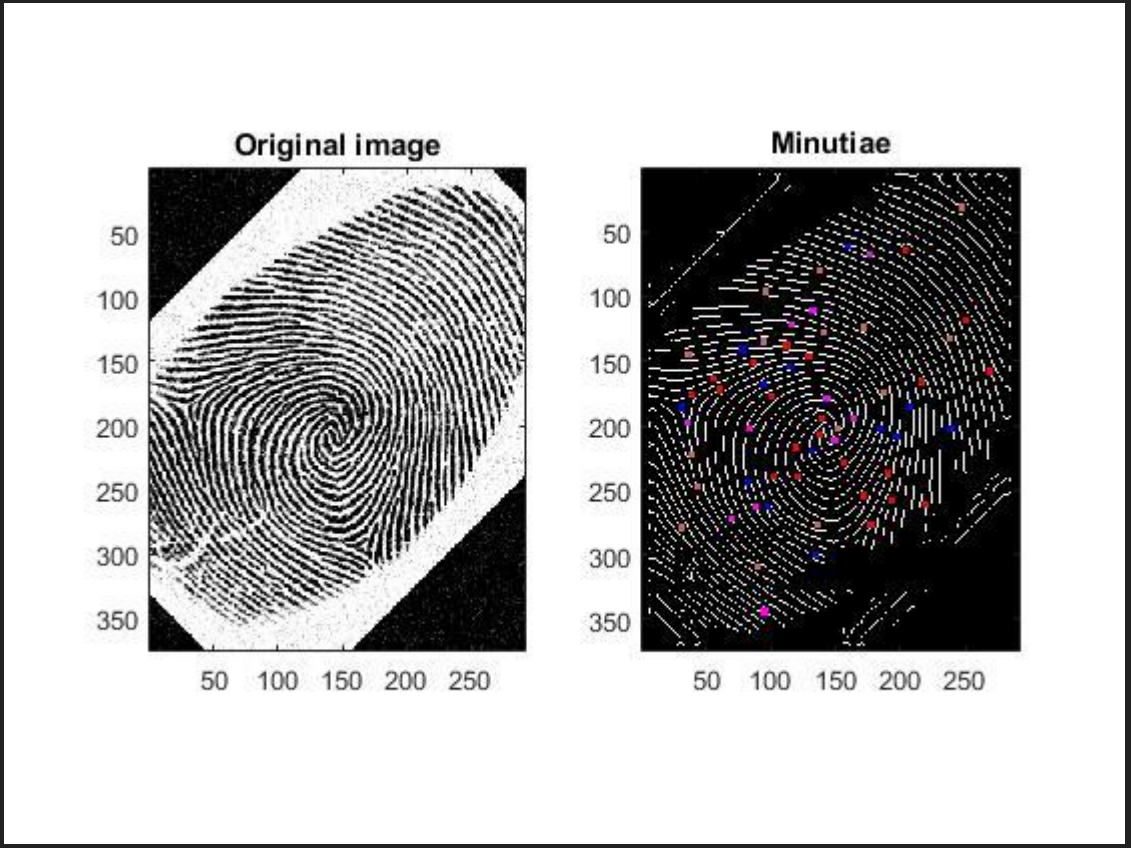
$$SM = sqrt(\frac{n^2}{a * b})$$

Where, a and b are the size of the transformed image after minutiae extraction

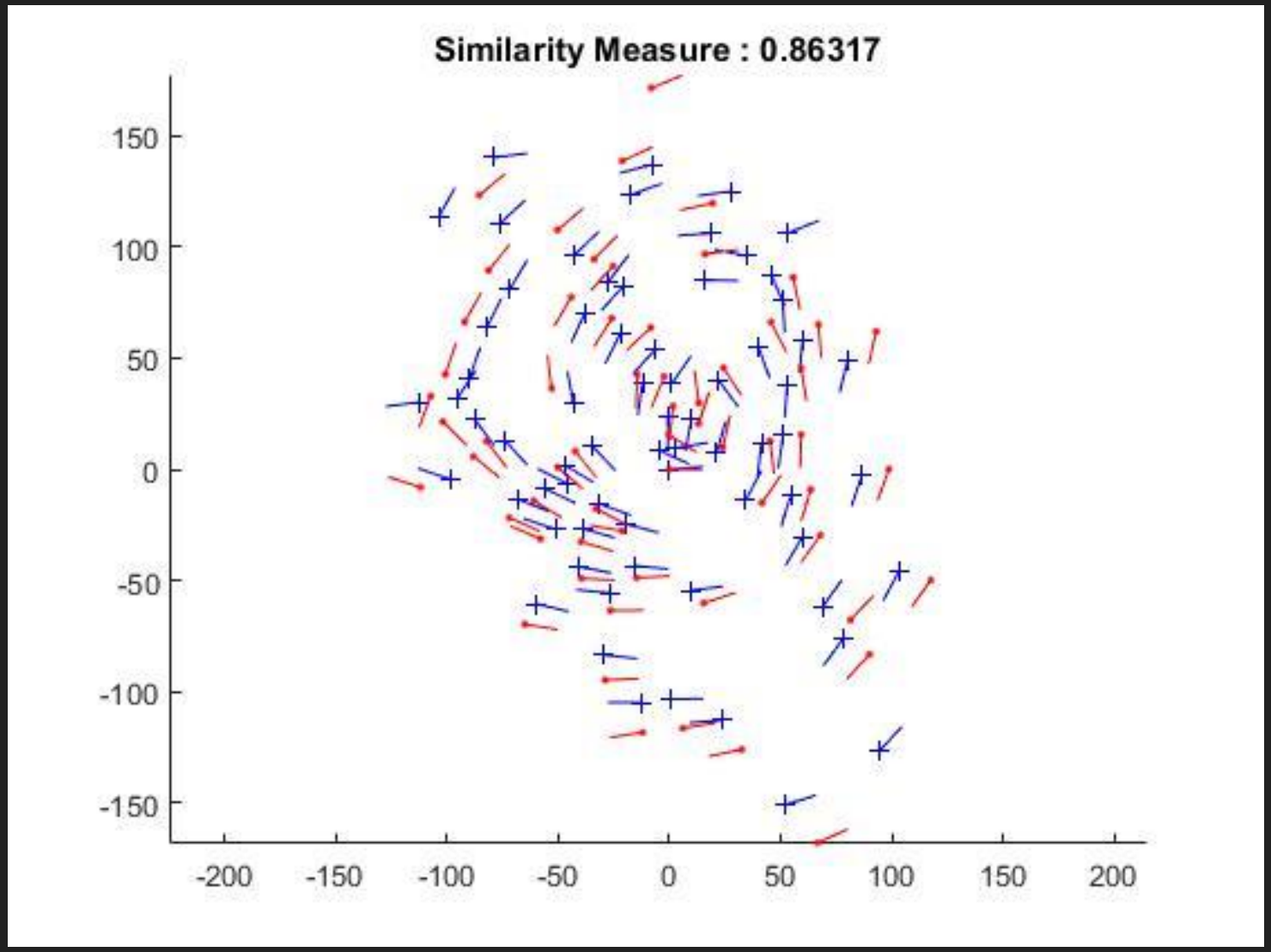
- From the graphs of False matching rate and False non-matching rate, it's found that the threshold for similarity measure is 0.48, which means two fingerprints are said to be matching if the similarity measure is more than 0.48
- Consider the following fingerprints,

- After applying the algorithm, we get…

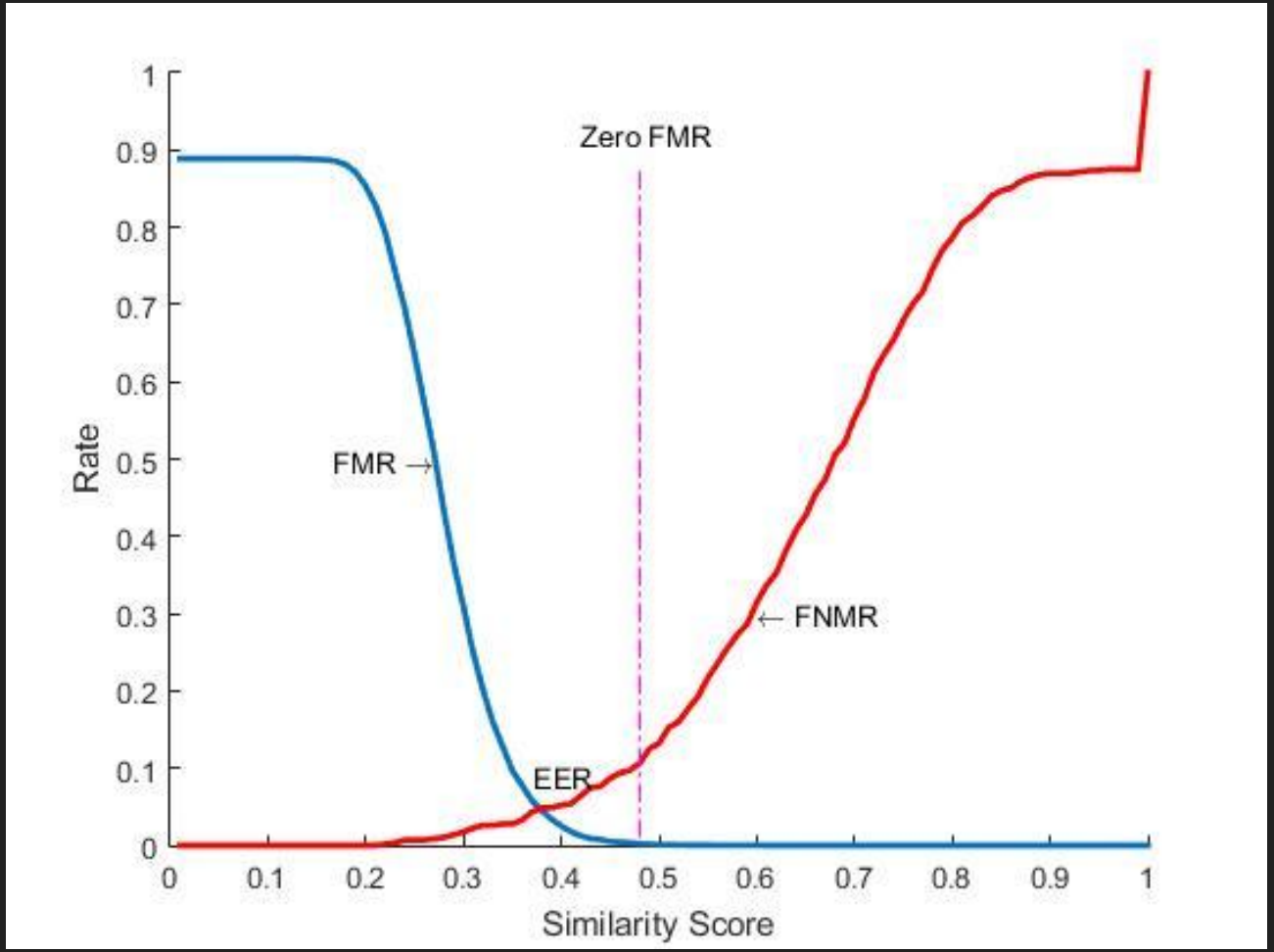




- We get a similarity measure of 0.86317 which means it's a MATCH, both the fingerprints are of the same person…



- The following graph shows variations between similarity score and the false matching and false non-matching rates and we find zero FMR at a similarity score of 0.48



Conclusion

Inferences

- The proposed algorithm is a simple approach towards matching two fingerprints by counting number minutiae pair with help of similarity measure
- The reliability of any automatic fingerprint system strongly relies on the precision obtained in the minutia extraction process
- Poor image quality damages the correct location of minutia
- There is a scope of further improvement in terms of efficiency and accuracy which can be achieved by improving the hardware to capture the image or by improving the image enhancement techniques. So that the input image to the thinning stage could be made better, this could improve the future stages and the final outcome

THANK YOU