

# A Review on Minutiae Feature Extraction of Enhanced Fingerprint Image

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**Abstract**— Fingerprint recognition is verifying the match between two fingerprints. Fingerprint recognition is mostly based on minutiae. In this paper the review on minutiae extraction is done after various fingerprint enhancement methods. Minutiae extraction common method cross-numbering is reviewed and how to remove false minutiae with segmented mask technique.

**Keywords**— Minutiae feature, fingerprint enhancement, Image segmentation, Enhanced thinning, Minutiae extraction, false minutiae.

## INTRODUCTION

Biometric features used for identification of a person identity. Basic biometric features involved voice recognition, handprints, iris recognition, fingerprint recognition etc. In this fingerprint recognition is most widely used and well known technique for identification of a person because it is unique and unchangeable. Fingerprint recognition is used for criminal investigation, for medical purpose, for security purpose etc. A fingerprint is formed from an impression of the pattern of ridges on a finger. A ridge is defined as a single curved segment, and a valley is the region between two adjacent ridges. [1] Fingerprint recognition is based on minutiae matching and minutiae are the major features of fingerprint using which comparisons of one print with another can be made. Fingerprint has mainly three types of pattern i.e. whorl pattern, loop and arch pattern as given below



*Fig.1*

## MINUTIAE FEATURE

Ridges and valleys are the structural characteristics of fingerprint images. The ridges are the single curved segment and valleys are the region between two ridges. The most commonly used fingerprint features are minutiae. Minutiae are the discontinuities in local ridge structure[2]. Minutiae features are used for matching two fingerprints. There are about seven main features of minutiae. They are basically ridge ending, bifurcation, enclosure, ridge dot, delta and hock. From these seven minutiae points two points are the main minutiae feature which are used for minutiae extraction i.e. ridge ending and bifurcation. A ridge ending is defined as the ridge point where a ridge ends abruptly. A ridge bifurcation is defined as the ridge point where a ridge forks or diverges into branch ridges

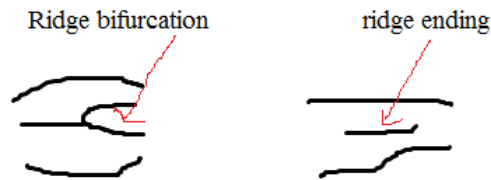


Fig. 2

## IMAGE ENHANCEMENT

Before minutiae extraction image enhancement is required in some low quality fingerprint images. Low quality of image occurs because of any skin problem or bad impression which causes degradation. To extract true minutiae points it is important to enhance the poor quality of the image. Ridge structure in fingerprint images is not always well defined and therefore an enhancement algorithm is needed to improve the clarity of ridges and valley structure. Image enhancement basic techniques are image segmentation, image binarization and gabor filter.

*Image segmentation:* A fingerprint image contains valid and invalid information both. Image segmentation is the process which decomposes an image into its two components which are called background and foreground component [10]. Foreground area is belonging to area of interest i.e. useful information and background component belongs to noisy or invalid information. To perform segmentation variance thresholding can be used. In this image is divided into two blocks and gray-scale variance is calculated for each block. If variance less than global thresholding than block is assign to be background and which is greater assign to foreground [2].

*Image Binarization:* Binarization method involves mainly four steps to carry out image enhancement i.e. local histogram equalization (LHE), wiener filtering, Binarization and thinning and morphological and filtering. In LHE contrast stretching is performed by making histogram uniform for each pixel. In wiener filtering noise reduction is performed by filtering on local neighborhood of each pixel. In Binarization and thinning grey level image is converted into binary image using global threshold. The Binarization process involves examining the grey-level value of each pixel in the enhanced image, and, if the value is greater than the global threshold, then the pixel value is set to a binary value one; otherwise, it is set to zero. The outcome is a binary image containing two levels of information, the foreground ridges and the background valleys [2]. In morphological and filtering false ridge lines are removed and fill the gaps with true ridge lines.

*Gabor filtering:* Gabor-based enhancement algorithm is focused on the characteristic of local ridge orientation and frequency simultaneity in spatial domain for improving the quality of fingerprint image [3]. Gabor filter are band pass-filter that have both frequency selective and orientation selective property. Hence these filters can be effectively tuned to specific frequency and orientation value [4]. The main steps of Gabor filtering are [5]:

*Step 1: Normalization* which increases the dynamic range between foreground and background.

*Step 2: Estimation of local orientation* which is a matrix of direction vectors representing the ridge orientation at each location in the image. It is estimated from the segmented image by employing the gradient information.

*Step 3: Estimation of local frequency* which is the inverse of the average distance between two consecutive peaks of the x-signature. It is computed from the segmented image and the estimated orientation.

*Step 4: Gabor filtering* which enhances the segmented image. It is based on the local orientation and frequencies around each pixel.

## MINUTIAE EXTRACTION

Minutiae extraction techniques are the next step after enhancing image. In this minutiae are extracted from the enhanced image [6]. Two fingerprint match if their minutiae matches. The main minutiae points are ridge ending and bifurcation points. Minutiae extraction technique basically contains three main steps:

*Binarization:* this process is useful for converting gray-scale images into binary images. After Binarization the image is transformed onto Skelton images. Minutiae extraction technique is performed on Skelton images.

*Thinning:* The objective of thinning is to find the ridges of one pixel width. The process consists in performing successive erosions until a set of connected lines of unit-width is reached. These lines are also called skeletons. An important property of thinning is the preservation of the connectivity and topology which however can lead to generation of small bifurcation artifacts and consequently to detection of false minutiae. Therefore some procedure aiming the elimination of these artifacts must be performed after thinning.

*Enhanced Thinning [10]:* Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. Ideally, the width of the skeleton should be strictly one pixel. However, this is not always true. There are still some locations, where the skeleton has a two-pixel width at some erroneous pixel locations. An erroneous pixel is defined as the one with more than two 4-connected neighbours. These erroneous pixels exist in the fork regions where bifurcations should be detected, but they have  $CN=2$  instead of  $CN>2$ . The existence of erroneous pixels may

- a) Destroy the integrity of spurious bridges and spurs,
- b) Exchange the type of minutiae points, and
- c) Miss detect true bifurcations,

Therefore, before minutiae extraction, there is a need to develop a validation algorithm to eliminate the erroneous pixels while preserving the skeleton connectivity at the fork regions. For this purpose an enhanced thinning algorithm is bid out.

### *Enhanced thinning algorithm*

Step 1: Scanning the skeleton of fingerprint image row by row from top-left to bottom-right. Check if the pixel is 1.

Step 2: Count its four connected neighbours.

Step 3: If the sum is greater than two, mark it as an erroneous pixel.

Step 4: Remove the erroneous pixel.

Step 5: Repeat steps 1 – 4 until whole of the image is scanned and the erroneous pixels are removed.

*Minutiae detection:* Cross-numbering concept is most common method to detect minutiae. This method involves the use of the skeleton image where the ridge flow pattern is eight-connected. The minutiae are extracted by scanning the local neighborhood of each ridge pixel in the image using a 3X3 window as in figure below [7].

P4	P3	P2
P5	P	P1
P6	P7	P8

Fig. 3

CN value is computed as half the sum of the difference between pairs of adjacent pixels in the eight-neighborhood as given below

$$CN = 0.5 \sum_{i=1}^8 |p_i - p_{i+1}|$$

Where  $P_i$  is the pixel value in the neighborhood of  $P$ . For a pixel  $P$ , its eight neighboring pixels are scanned in an anti-clockwise direction as above in fig.

After the CN for a ridge pixel has been computed, the pixel can then be classified according to the property of its CN value. As shown in Figure below, a ridge pixel with a CN of one corresponds to a ridge ending, and a CN of three corresponds to a bifurcation[8].

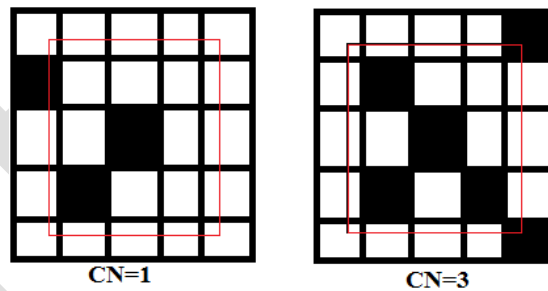


Fig. 4

CN=1 is ridge ending point and CN=3 is bifurcation point.

### REMOVING OF FALSE MINUTIAE

The minutiae points obtained in the above step may contain many false minutiae. This may occur due to the presence of ridge breaks in the given figure itself which could not be improved even after enhancement. This results in false minutiae points which need to be removed. These unwanted minutiae points are removed in the post-processing stage. False minutiae points will be obtained at the borders as the image ends abruptly. These are deleted using the segmented mask. As a first step, a segmented mask is created. This is

created during segmentation carried out in the stage of pre-processing and contains ones in the blocks which have higher variance than the threshold and zeros for the blocks having lower variance. This segmented mask contains all ones in the regions where the image is located and all zeros at the other places.

To know if a minutiae point is valid or not, a local window of size  $11 \times 11$  is taken in the segmented mask at the location of the minutiae point and the total sum of the window is computed. If the sum is lesser than 121, then the point is invalid as it would be on the borders. If the sum is 121, it means that the point is not on the border and hence it has to be preserved. Thus, minutiae at the borders are removed preserving only those inside the figure. For the deletion of minutiae inside the figure which would occur due to ridge breaks, a window of size  $11 \times 11$  is taken around each minutiae point keeping it at the centre of the window and then is checked for any other minutiae that lie in the block. If other minutiae exist in that block, all the minutiae in the block are deleted. Thus, the minutiae points resulting from ridge breaks are eliminated. Though this process helps in removing false minutiae, it also poses a risk of eliminating closely placed minutiae points even though they are real[9].

## Conclusion

This paper reviewed on various enhancement and minutiae extraction technique. Crossing number method is able to accurately detect all valid bifurcations and ridge endings from the thinned image. However, there are cases where the extracted minutiae do not correspond to true minutia points. Hence, false minutiae removal method is implemented to validate the minutiae. Future work can be done on the statistical theory of fingerprint minutiae.

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