Fingerprint Enhancement and Feature Extraction using Thinning and Minutiae Extraction of Ridge and Bifurcation

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***Abstract*— This research article paper discusses the enhancement of a fingerprint impression with the help of anisotropic filter. The main aim of this paper is to discuss a fingerprint recognition system by extracting the minutiae of a fingerprint impression after applying the thinning and the minutiae extraction algorithm. The result provides better fingerprint impression with higher matching accuracy.**

***Index Terms*—Fingerprint Recognition, Feature Extraction, thinning, Minutiae, CSI (crime scene investigation).**

I. INTRODUCTION

Fingerprint impressions play a very important role in identifying criminals in the court of law. Fingerprint recognition systems are widely used for nailing down the criminals or identifying an innocent person in the CSI (Crime scene investigation) departments. It is also used in the passport office, adhaar centers for issuing personal ids. Hidden fingerprints which are found in various objects are called latent fingerprints. Latent fingerprints can be acquired with the help of chemical dusting or by clicking a simple photograph. Latent fingerprint impressions are found to be of poor quality because of the presence of large amount distortion. It can also be affected by the presence of scars, wounds, poor background light and small common area. The three main steps of fingerprint recognition system are pre-processing, feature extraction and post processing. Fingerprint impressions which are of bad quality can be enhanced in the pre-processing stage prior to the feature extraction process in order to make the image more informative. Feature extraction can be done by detecting the minutiae points (consisting of ridges and valleys).Ridges are the dark regions found in the fingerprint impression and valleys are white regions located in the fingerprint impressions. Fingerprint play a very important role in biometric application. Fingerprint pattern does not change or decay with age.

II. LITERATURE SURVEY

Jianjiang Feng and Anil K. Jain *et al.* [1], in this paper they work on-FM model based fingerprint reconstruction from Minutiae template. Minutiae representation is the most a popular fingerprint representation method. It has been believed that the minutiae template does not contain sufficient information to allow the reconstruction of the original fingerprint image. This belief has now been shown to be false, several algorithms have been proposed that can reconstruct fingerprint images from minutiae templates. But these reconstruction techniques have a common weak point such as many spurious minutiae, not included in the original minutiae template are generated in the reconstructed image. And some of these techniques can only reconstruct a partial fingerprint. They have proposed an algorithm which only reconstructs the whole fingerprint and the reconstructed fingerprint have very few spurious minutiae.

Arun Ross, Sarat C.Dass, Anil K.Jain *et al.* [2], in this paper they work on-Estimating Fingerprint Deformation. Fingerprint matching can be affected by the presence of non-linear distortion. This issue occurs in fingerprint impression during the image acquisition process. The deformation causes blur in the minutiae points and ridge curves. During direct contact in the fingerprint sensors, the image acquisition process introduces non-linear distortions in the ridge structure due to the non-uniform finger pressure applied by the person on the sensor and the elastic nature of the human skin. For reliable matching, these non-linear deformations must be accounted before comparing two fingerprint images. In this paper, they propose a average deformation model for a fingerprint impression. Results show this average deformation model can improve the matching accuracy result of a fingerprint matcher.

Arun Ross, Jidnya Shah and Anil K. Jain *et al.* [3], in this paper they work on-Towards reconstructing fingerprints from minutiae points. This algorithm

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uses minutiae triplet information to estimate the orientation map of the parent fingerprint. The estimated orientation map is consistent with the underlying ridge orientation. They discuss a classification technique that uses minutiae information alone to find the class of the fingerprint. They show that the minutiae information can give out important details such as orientation field that can be used to reconstruct the original fingerprint image. Results indicate that the minutiae also contain class information of a fingerprint. They also demonstrate that the fingerprint image can be reconstructed using the minutiae template.

Anil K. Jain, Fellow, IEEE, Yi Chen , IEEE, and Meltem Demirkus, IEEE *et al.* [4]-Pores and Ridges: High-Resolution Fingerprint matching using level 3 features They propose a hierarchical matching system that uses level 1,level 2 and level 3 features. These features were extracted from 1000ppi fingerprint scans. With the advances in fingerprint sensing technology, many sensors have dual resolution (500ppi/1,000ppi) scanning capability. Increasing the scan resolution alone does not provide any performance improvement in fingerprint matching, unless an extended feature set is used. They determine how much performance gain one can be achieved by using Level 3 features in AFIS .There is reduction of 20 percent in equal error rate (EER) of the matching system when this method is used.

Shlono Greenberg, Mayer Aladjem, Daniel Kogan and Itshak Dimitrov *et al.* [5], in this paper they work on- Fingerprint Image Enhancement using Filtering Techniques. One of the most important steps in automatic fingerprint identification and classification is to extract minutiae from fingerprint images. Minutiae are the discontinuities present in the fingerprint pattern, mainly referred to as terminations and bifurcations. They propose two methods for the enhancement of a fingerprint image. The first one is done with the help of local histogram equalization, wiener filtering and binarization. The second one is carried out using anisotropic filter. In this research paper, the results achieves are compared with other techniques and both the techniques show improvement in the minutiae detection process.

III. DESIGN AND IMPLEMENTATION

A. Pre-processing stage

The employment of the enhancement technique is done in the post-processing stage. We have used anisotropic diffusion to enhance the poor quality fingerprint impression. The enhancement stage plays a very important role in image processing because it helps to improve the low contrast images. The result which is obtained after the enhancement stage is much better as compared to the original fingerprint impression. But the degradation of an image takes place after the employment of the enhancement algorithm. Anisotropic diffusion helps in enhancing the features of an image. Image enhancement technique are of two types .They are spatial and frequency domain techniques. Spatial domain techniques are be further divided into point, mask and global enhancement operators.

Anisotropic diffusion technique helps in improving the quality of the ridge and valley region. Anisotropic enhancer is a powerful image enhancer which is based on the partial differential equation of a heat transfer. Anisotropic filter helps in getting rid of the speckle noise from the fingerprint impression. The degradation of the image is possible after applying the enhancement algorithm. Hence the enhanced fingerprint image is binarized and thinned during the feature extraction step.

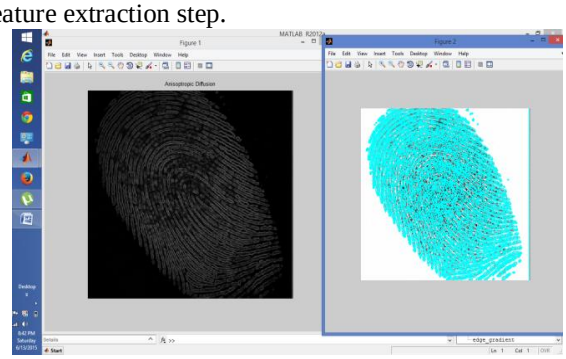

Figure 1: Fingerprint enhanced using anisotropic diffusion.

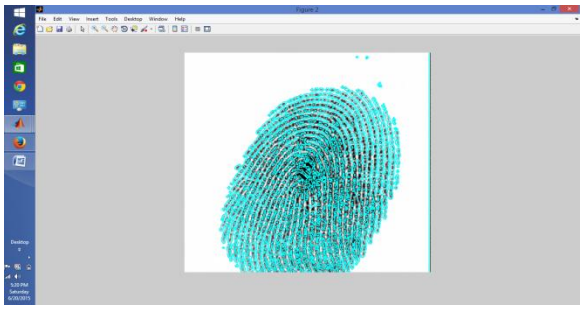

Figure 2: Fingerprint enhanced image mapped with colored boundaries.

B. Feature extraction step

Feature extraction is the carried out after the enhancement of the fingerprint impression. We have extracted the minutiae points of the fingerprint impression during the feature extraction process. The feature extraction step is done in three steps. They are binarization, thinning and minutiae extraction.

C. Binarization

Binarization is the first step involved in the

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minutiae extraction process. Binarization is used to convert the 8 bit gray scale fingerprint impression in to 1 bit black and white image. In the black and white image, ridges have zero value and valleys have one value. Hence, the ridges are black in colour and the valleys are white in colour. This black and white image is also called the binary image. The colour which is used to define the objects in the image is called the foreground colour and the rest of the image is known as the background colour of the image. Locally adaptive binarization can be also used to convert the gray scale fingerprint impression into binarized or the black and white image. Segmentation and the thresholding process can also be used in the binarized images.

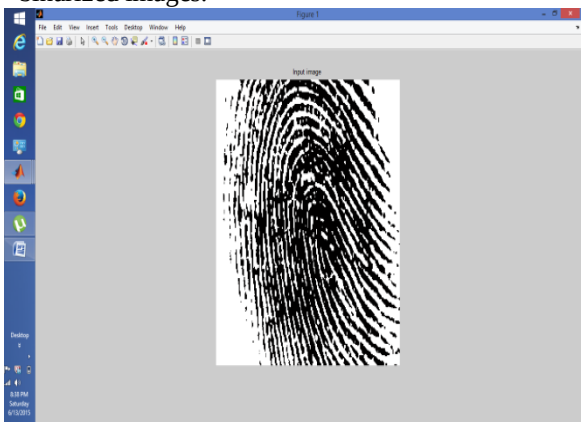

Figure 3: Output obtained after the binarization of the fingerprint impression.

D. Thinning

Thinning process is the second step involved in the minutiae extraction process. After the thinning process is applied, ridges in the fingerprint impression become one pixel wide. The main purpose of the thinning algorithm is to eliminate the redundant pixels in the image. Thinning process can be carried out with the help of parallel thinning algorithm. The redundant pixels are first stored in small image windows (3*3). Then the redundant pixels can be removed after several scans. But the parallel thinning algorithm is not a very efficient algorithm because it takes too much time. The binarization process is applied in the first step in the fingerprint impression because it contains the maximum grey intensity values. The parallel thinning algorithm is complex in nature. Thinning process can be done using the morphological thinning operator. Thinning process works only on black and white images. Thinning step plays a very important role in the minutiae extraction process because it reduces the amount of data to be processed. It also reduces time. It is also helpful for the extraction of the minutiae features. Shape analysis can also be done using the morphological thinning algorithm and minutiae extraction process becomes easy to use when it is applied on line like patterns.

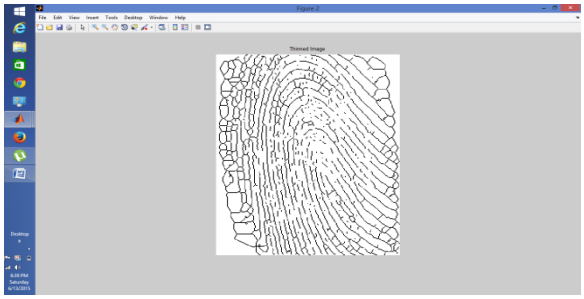

Figure 4: Thinned fingerprint impression.

E. Minutiae extraction

Minutie marking is done in the minutiae extraction process .This step produces a better result when larger number of minutiae are detected. This step is applied after the image pre-processing step. It mainly works on the pixel value (1 or 0).There are two methods involved in the minutiae extraction process. The first method deals with value one and the second method deals with value zero. The binarization process is carried out with the help of mask. Minutiae are points in the fingerprint impression which has one neighbour or more than one neighbour. It is difficult to find out the orientation estimation in poor fingerprint impressions. Hence the enhancement algorithm is applied in the pre-processing step. We have used the anisotropic filter in order to enhance the poor quality fingerprint impression. This forms reliable algorithm and it helps in producing less error. The fingerprint verification stage works by re-examining the gray scale image by several stage. It also assigns on or two class labels which involves ridge bifurcation and ridge ending. The minutiae extraction result helps to provide better matching accuracy on database fingerprint impressions. More information is obtained for the pattern recognition process. When the original image is re-examined, the errors which occurs in the sequential processing is eliminated. Improved system accuracy is obtained in the pattern recognition process. Ridge bifurcation is represented in red box and ridge ending is represented in blue box.

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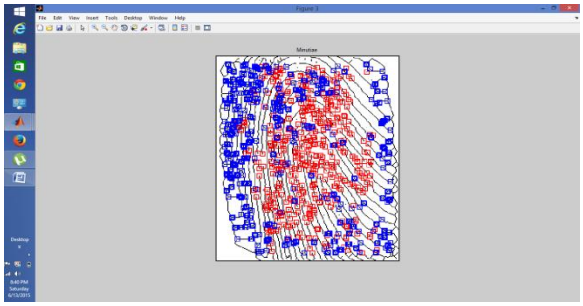

Figure 5: Minutiae detection: red box represents ridges and blue box represents bifurcation.

F. Image Segmentation

Segmentation can be of two types. They are region based and object based segmentation. Segmentation can be done till the desired object is detected. Segmentation can also be done to connect the broken paths. Segmentation can be useful in the field of computer process and automatic target acquisition. Segmentation in based on the discontinuity and similarity of the changes in the intensity of the edges. Segmentation can be done with the help of Thresholding, region growing and region splitting.

G. Point, line and Edge Detection

Edges pixels are the points where the intensity or the edges changes abruptly. Edge detectors such as Sobel filter are used to find these edge pixels. First order derivatives produce thick edges. Second order derivatives produce finer edges such as thin lines, isolated points and noise. The second order derivatives produce double edge response such as ramp and step intensity. The second order derivative also helps in determining the transition of images from light to dark or dark to light area. Edge detection can be performed in order to segment the images. Edge models works on the basis of the intensity profiles.

IV. CONCLUSION

From the study and analysis of matching fingerprint impressions after enhancing the poor quality fingerprint impression and after obtaining the result of binarization, thinning and minutiae extraction process, we have come to the conclusion that it helps in providing an efficient output with higher accuracy.

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