Minutiae Extraction Based on Propriety of Curvature

Abbad Khalid, Tairi Hamid, and Aarab Abdellah

***Abstract*— Fingerprint verification algorithms need two majors steps; enhancement of image and minutiae extraction. Our approach uses Short Time Fourier Transform (STFT) Analysis to enhance fingerprint. The foreground region mask, local ridge orientation and local frequency are all estimated by STFT algorithm. The novel approach of minutiae extraction is based on the extraction of the map contour of fingerprint and then finding minutiae using the global and local proprieties of contour. We compare our proposed approach with the alternative approach of minutiae extraction and the results show the performance of our technique.**

***Index Terms*—Contour, corner, curvature, MINDTCT, minutiae extraction, NIST, STFT enhancement.**

I. Introduction

The quality of fingerprint images and extraction of minutiae have an important role in the performance of automatic identification and verification. In general, the minutiae extraction algorithm starts with a preprocessing for improving the quality of images without changing the local and global properties of the image. The fingerprint image can be characterize by the features as core and delta or as minutiae represent the end of ridge or the bifurcation .the methods based on minutiae are sensitive to this stage .Any missing minutiae or false minutiae can degrade the performance of the matching algorithm.

In literature search we found many techniques for enhancement, Hong et al proposed an effective method based on Gabor filters [1]. Gabor filters have both frequency ridge and orientation ridge properties; the frequency ridge depends on orientation ridges. Chikkerur et al proposed an efficient implementation of contextual filtering based on short-time Fourier transform (STFT) [2] that requires partitioning the image into small overlapping blocks and performing Fourier analysis separately on each block. The orientation, frequency and mask region of image are all simultaneously estimated.

The Several approaches to automatic minutiae extraction are two categories techniques [3]-[4], there are different from one other. The most of these methods transform fingerprint images into binary images, the images obtained are submitted to a thinning process which allows for the ridge line thickness to be reduced to one pixel finally, a simple image scan allows for locating the pixels that correspond to minutiae [5]-[6]. On the other hand, other techniques are based on ridge line, where the minutiae are extracted directly from gray images [7].

To remind, our paper is organized as follows. Enhancement of images and minutiae extraction algorithm is briefly introduced in section 1. In section 2 presents minutia extraction using by NIST algorithms; our approach are described in section 3, the results of our approach are described in section 4, followed by the conclusions and future work considerations.

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II. Minutiae Extraction Using Package NIST

Minutiae points represent minor and unique details in fingerprints. They are the most reliable and distinctive features. MINDTCT (fingerprint minutiae detector)[8] is software the National Institute of Standards and Technology (NIST) software , it takes as input a fingerprint image and outputs the set of minutiae characterized with their corresponding locations, orientations, types, reliability indicators and nearest neighbors.

Fig. 1 shows the flowchart of Minutiae detection using MINDTCT

Like any treatment of image begins with enhancement of the image, MINDTCT has adopted the method of histogram equalization, such application has address binary image where black pixels represent ridges and white pixels represent valleys in a finger, each pixel of the input image must be analyzed to determine whether it should be given a black or white pixel. A pixel is assigned a binary value based on direction of ridges. Thus this method can generate the images that represent areas of low contrast, orientation of image, the areas of high curvature, and the image that represents the quality of areas, the most important step is the detection of minutiae It s scan the image horizontal and vertical row of pixels in the image, searching for sequences that match the searched pattern, followed by elimination of false minutiae. And the end this method affects the quality to each minutia based on maps generated.

Fig. 2 illustrates the searched pattern in fingerprint.

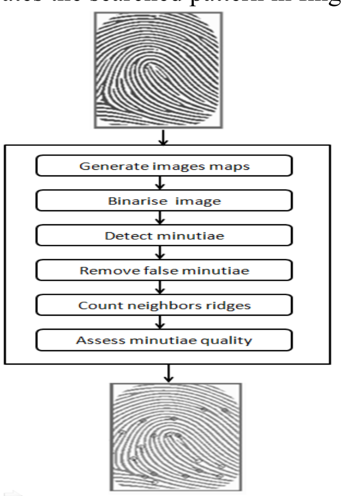

Fig. 1. The minutiae detection using MINDTCT [8]

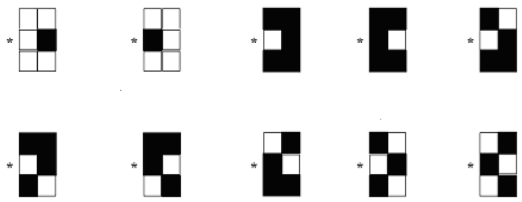

Fig. 2. Pixel patterns used to detect minutiae [8].

This method has disadvantages, it does not able to extract minutiae in areas with low contrast, it cannot locate the area of interest in the image .To solve this problem we proposed a method based on the minutiae extraction based on properties contours of fingerprint

III. Approach Proposed

Our method brings improvements on two steps; minutiae extraction and enhancement of image.

A. .Minutiae Extraction

Our method for extraction of minutiae is based to find local high curvature in contours of the image; the both minutiae type ending and bifurcation are characterized by high curvature contour.

Fig. 3 shows the localization of minutia ending and bifurcation using curvature of contour.

Fig. 4 shows the steps for extraction minutiae.

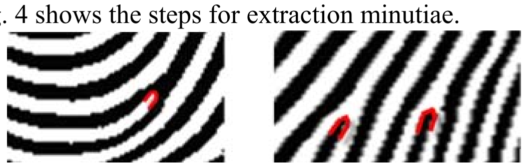

Fig. 3. Bifurcation and ending extracted using our curvature of contour

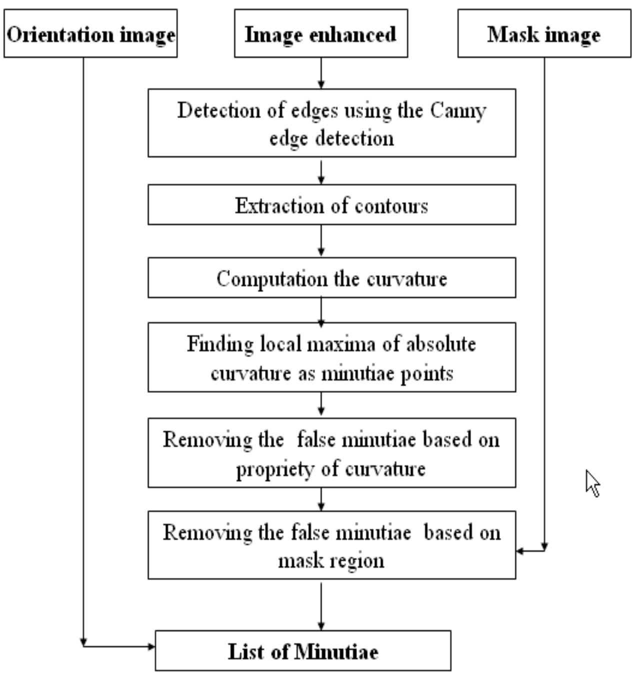

Fig. 4.Overview of our proposed method for extraction minutiae

Fig. 5 illustrates the results of method adopted to extract minutiae from binary image enhanced.

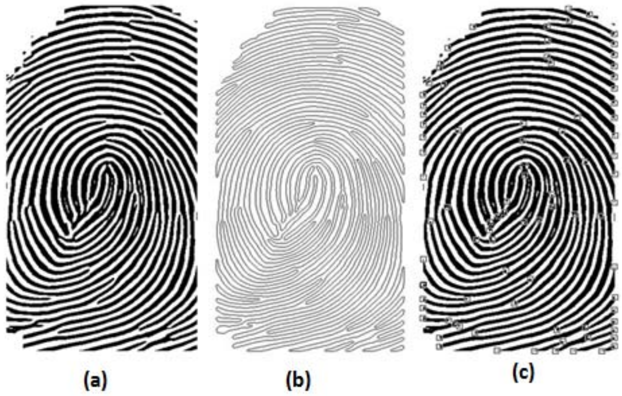

Fig. 5. (a)Image enhanced image, (b) Canny edge, (c) Map, Extraction of minutiae

The smoothing of images is an important operation in image processing used to reduce noise and small details that corrupts the information, before extraction of contour. In this sense, we use Gaussian smoothing to eliminate small variation of ridge before extraction of contours.

The Gaussian smoothing operator is a 2-D convolution operator, it is similar to the mean filter, but it uses a different kernel.

The contour convolved with the Gaussian smoothing kernel g is denoted by:

$$\mathrm{Img}_{smothing}^{j} = \mathrm{Img}_{smothing}^{j} \otimes g$$

where g is digital Gaussian function with σ is the standard deviation of the distribution, the implemental result proposed with σ =3.

After extraction of contours, the curvature value of each pixel of the contour can be calculated using (1):

$$C_i^j = \left(\Delta^2 x_i^j \Delta^2 y_i^j - \Delta^2 x_i^j \Delta^2 y_i^j\right) / \left(\left(\Delta x_i^j\right)^2 + \left(\Delta y_i^j\right)^2\right)^{1,5} \quad (1)$$

Where $\Delta x_i^j = (x_{i+1}^j - x_{i-1}^j)/2$, $\Delta y_i^j = (y_{i+1}^j - y_{i-1}^j)/2$, $\Delta^2 x_i^j = (\Delta x_{i+1}^j - \Delta x_{i-1}^j)/2$ and $\Delta^2 x_i^j = (\Delta x_{i+1}^j - \Delta x_{i-1}^j)/2$.

The all local maxima of curvature function are stored in the initial list of minutiae points.

The global curvature characteristic are used to eliminate the false minutiae using the region of support (ROS)[9]. ROS of minutia is defined by the segment of the contour bounded by the minutia's two nearest curvature minima. The ROS of each minutia is used to calculate a local threshold adaptively, where u is the position of the minutia on the contour, L1+L2 is the size of the ROS centered at u, and R is a coefficient:

$$T(u) = R \times \overline{C} = R \times \left(\sum_{i=u-L_2}^{i=u+L_1} |C(i)| \right) / \left(L_1 + L_2 + 1\right) \quad (2)$$

where $\overline{C}$ is the mean curvature of the ROS. If the curvature of the minutia candidate is larger than $T(u)$ then it is declared a true minutia; otherwise it is removed from the list. The adaptive threshold is given by (3):

$$T = R \times \overline{C} = R \times C_{\max} \times a / b \quad (3)$$

where the vertex (0, *b*) of the ellipse will be a curvature maximum, and this ellipse is define by $f(x)=\left[b^2-(bx/a)^2\right]^{1/2}$, with $x\in[-a,a]$ and b>a.

The minutia curvature should have a relatively sharp angle. If we knew the angle of each minutia on a contour, it would be easier to differentiate true minutia from false minutia, but also taking the global properties in considerations can be more robust to extract the true minutia.

Fig. 6 shows the minutia with similar local properties but different global properties. The angle C1 and C4 are equal but the distance C5C6 longer than C2C3.

B. STFT Enhancement

We know that the performance of fingerprint matching depends essentially on the quality of the images. We are used the fingerprint image enhancement algorithm based on Short Time Fourier Transform (STFT) Analysis, this algorithm adopts a probabilistic approach to simultaneously yield the local ridge orientation and the ridge frequency information using short time Fourier analysis. STFT analysis also yields an energy map that may be used as a region mask to distinguish between the fingerprint and the background.

Fig. 7 presents an overview of the proposed approach.

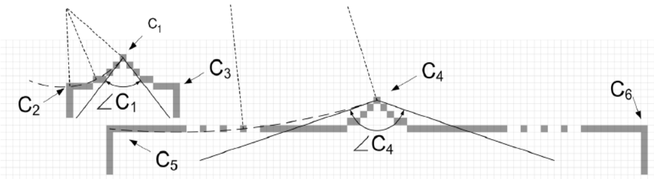

Fig. 6. Minutia with similar local properties but different global properties[9].

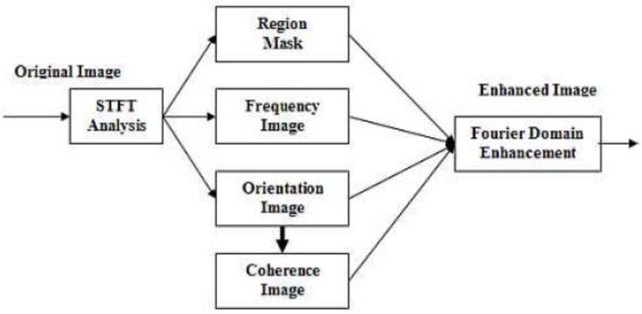

Fig. 7. Overview of the enhancement using STFT

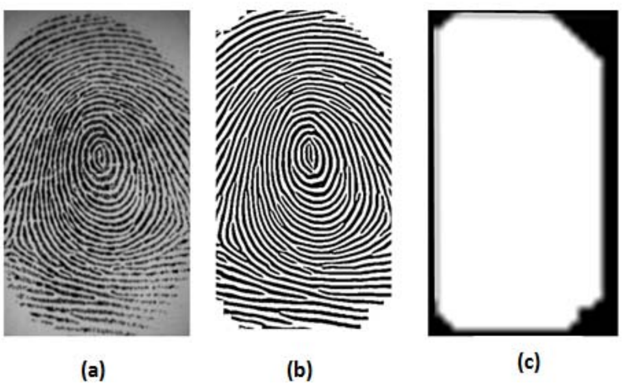

Fig. 8. (a) Original image, (b) enhanced image and (c) region mask

Fig. 8 shows the example of original image, enhanced image and the region mask, in order to illustrate the degree of enhancement of STFT

IV. Our Experimental Evaluation

In order to evaluate the performance of our proposed method, we have chosen the images from the public Database fvc2002db2 [10-11], and we compare it with minutiae extraction using NIST [8], the process is apply to same image these methods and show the differences between these methods, comparing the position of minutiae extracted and the messing minutiae and false minutiae.

Fig. 9 shows plot the sets of minutiae extracted with our method and sets of minutiae extracted with package NIST on the images.

In order to show the improvement objectively our method, we need to compare the results statistically of our method and other, we are run two programs of these methods to list of image contain 38 images in database FVC2002-DB2 and the results are shown in table I.

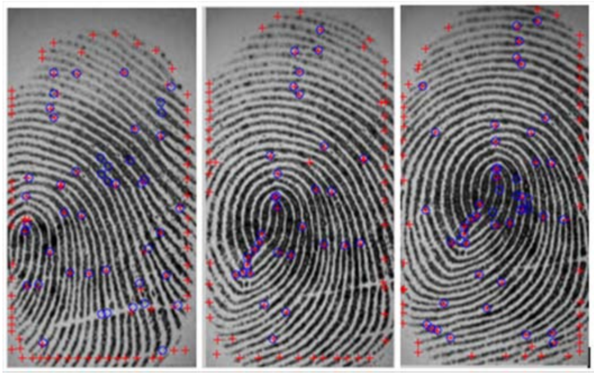

Fig. 9. Minutiae using MINDCT with o blue color and minutiae with our method + red

TABLE. I. The results of our method and MINDTCT

Extraction of minutiae	Average of Missing minutiae	Average of False minutiae
MINDTCT extraction of minutiae	0.74	1.71
Our method	0.21	1.05

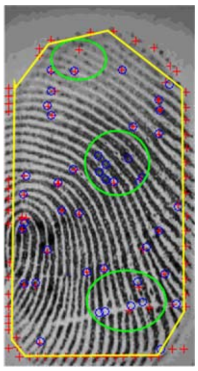

Fig. 10. Region of interest and the areas of minutiae differed between two approaches

The difference between minutiae detection with our method with another method that is that our method can detect the minutiae in the low contact area, the use of STFT improves the quality of the image, therefore the problem of low contact in the image is solved, on the other hand our method reduces the number false minutiae in case of power peak ,STFT estimate the continuity of ridge, finally our method cannot considerer the pores as minutiae, the fact extract the contour of ridges not extract the contour around pores , method using by NIST trying to solve problem based on step of elimination of false minutiae that is not always valid. The minutiae detected in boundary with our method are easy eliminated with region mask calculated STFT enhance.

Fig. 10 shows the region of interest in bounding by closed shape colored yellow and the areas with green color illustrate really the difference between our method and other.

V. Conclusion

Our proposed the method performs the extraction of features with these steps: extract the maxima in map contour and eliminate the false minutiae using the properties of curvatures. We have compared with popular minutiae extraction and we are found the good accuracy with our technique. As future work, we will focus on matching technique using pores and minutiae extracted with our method as features for fingerprint matching.

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