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Reliable fingerprint minutiae points' recognition using distance method algorithm

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Abstract
Fingerprint Recognition is one of the most popular biometric technique used for person identification and authentication. It mainly involves minutiae extraction and matching but shows drawback with handling of low quality impressions. This paper presents a strong minutiae extraction technique for fingerprint recognition with the help of distance method algorithm. It involves enhancing, binarising of fingerprint to extract valid minutia points using 3*3 window. The combination of multiple methods like segmentation using Morphological operations, thinning, false minutiae removal, minutia marking with special considering the triple branch counting and matching in the unified x-y coordinate system executing a two-step transformation. We proposed a simple strategy to filter out valid minutia points from several false minutiae points which increases the output efficiency.

Keywords: Minutiae, Ridge, Bifurcation, Crossing number, Fingerprint matching, false accept rate (FAR).

1. Introduction

Biometrics are the automatic recognition method of physiological (e.g. fingerprints, retina, iris etc.) and behavioral characteristics (e.g. signature) of an individual. Among all other biometric techniques, fingerprint recognition is by far the most popular and reliable technique because of its easiness of use, reliability, and non-interfering in privacy. Unlike all other biometric techniques, fingerprints remain persistent throughout age and cannot be easily distinguished. Thus, this technique is widely used in many other applications.

Skin on human fingertip contains ridges and valleys which together forms distinctive pattern known as Fingerprints. It is shown that each person have its own unique fingerprint. However, fingerprints are not distinguished by its ridges and valleys but by a features called Minutia that are basically some abnormal points present on the ridges. It is the position and orientation of these anomalies that are used to represent and match fingerprints.

Minutiae are the point of interest in fingerprint. There are several kinds of minutiae present in fingerprint like Ridge ending, Ridge bifurcation, ridge enclosures, spurs and crossover[1]. But the main among these all are Ridge endings and Ridge bifurcation. Ridge ending is a point in the fingerprint at which the ridge terminates or ends abruptly. Ridge bifurcation is a point at which a ridge gets split into two ridges. Short ridges are shorter than the average ridge length. Minutiae are the important features to be consider for two fingerprints not to be identical.

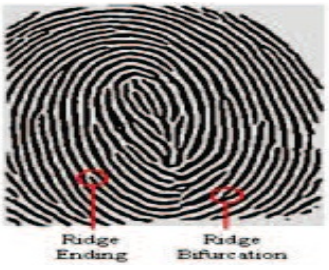

Fig1: Fingerprint minutia (Ridge ending and Ridge bifurcation)

Fingerprint Recognition basically includes two domains: one is Fingerprint verification and the other is Fingerprint identification [2]. Verification is basically a one to one process used to verify the authenticity of a person by its fingerprint whereas Identification is a one to many process used to specify one's person identity by its fingerprint.

literature review

There has been a lot of work that already done in the field of fingerprint identification. Basically, there are lot of different techniques and various kind of algorithms that are used in different stages of fingerprint recognition like enhancement, thinning, false minutia removal etc. Some of the techniques that are used are:

Minutiae extraction technique – This technique mainly deals with the fingerprint through its local features i.e. ridge ending or termination and ridge bifurcation. This technique is the base for most of the fingerprint gadgets in current world. Our proposed algorithm is also based on this technique.

Pattern based matching technique – It mainly involves feature extraction and template generation from a series of ridge so as to oppose the discrete points. It need large storage of template and are sensitive to placement of finger.

Image based matching technique – It involves the matching of global features of whole fingerprint image. It is an advanced and newly developed technique for fingerprint recognition.

One of the minutia based technique is Distance based algorithm in which distance between different minutiae is calculated after the image gets extracted. It is mainly ideal for matching one fingerprint with two or more stored templates. The proposed work will be discussed in next section.

work done

Fingerprint recognition consist of the following algorithm-

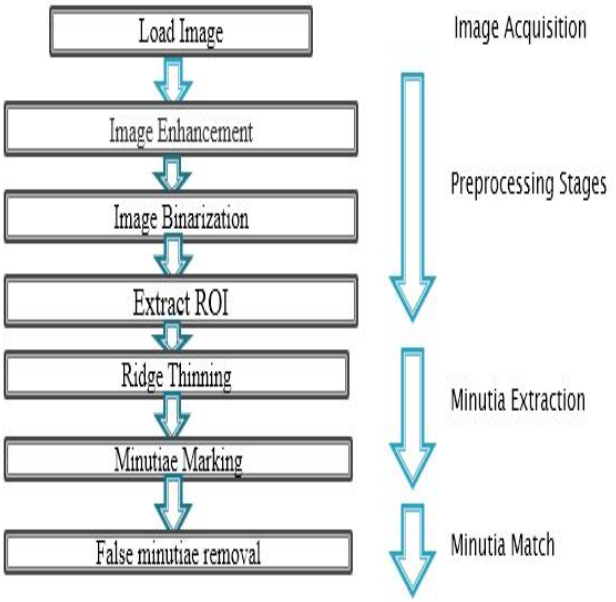

Fig 2: Fingerprint recognition algorithm

The detailed explanation of each stage with the proposed changes in each stages to obtain a better output.

Image Enhancement – It is mainly done in order to improve the image quality and make it clearer. Since most of the images of the fingerprint lack clarity [4]. So, image enhancement is one the major step in order to improve the efficiency of matching. It mainly increases the contrast and connects the false broken points in ridges to get a better result. In this, Histogram equalization, Fourier transform techniques and image binarization is basically used for image enhancement.

I. Histogram equalization – It mainly used to expand the pixel value distribution so as to increase the known information. It is done using the MATLAB function histeq ().It mainly enhance the contrast of image as we got in Fig 3(a).But sometimes histogram equalization produce not accurate output[3]. So, instead of histogram equalization, we can used image adjustment based on the threshold in order to obtain a better result. In this, we used a MATLAB command imadjust ().It is shown below in Fig. 3(b).

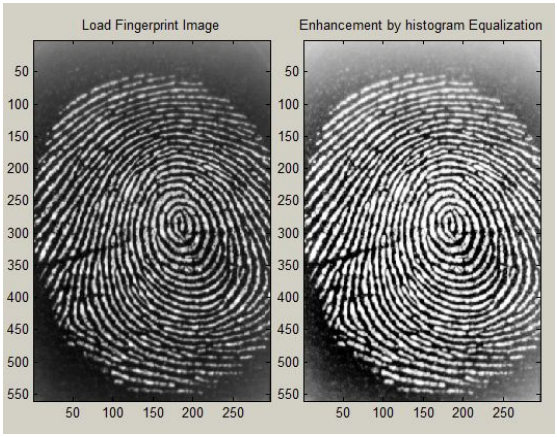

Fig 3 (a): Left Original fingerprint image, Right – image after histogram equalization.

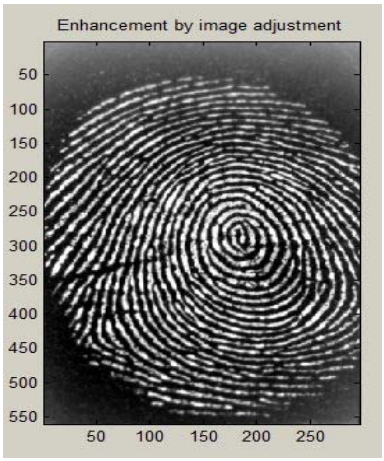

Fig 3(b): Image after image adjustment

II. Fourier transform – It is mainly done to find the frequency of a pixel. In this, the image gets divided into several block so that each specific block is get enhanced by its dominant frequency. Then, the FFT of block is multiply by its magnitude a set number of times. This mainly improves falsely broken points in ridges which are usually connected. The output after Fourier transform is shown in Fig.4.

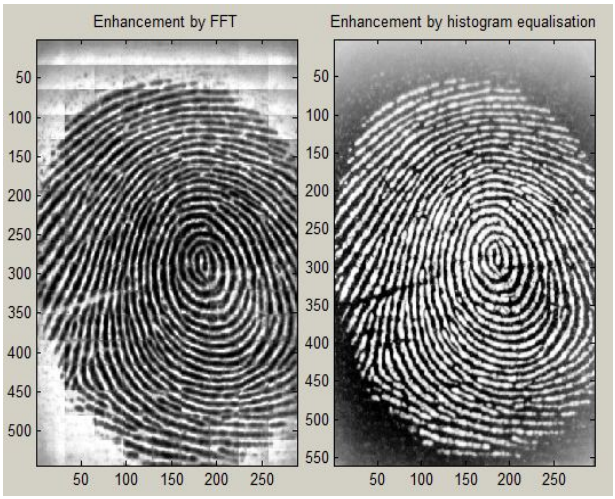

Fig 4: Left image after FFT, Right image after histogram equalization enhancement

III. Image Binarization – Since fingerprints are taken as grayscale image, it usually varies in intensity. In this, the fingerprint image is firstly gets transformed 256-level image into a 2-level image which gives the same information. In this, the object pixel is given a value '1' whereas the background pixel is given a value '0'.Then, finally the binary image is created by coloring each pixel either white or black based on pixel label. In this, locally adaptive binarization method is adopted to perform binarization. In this method, the mean intensity value is calculated for each block of image, then the pixel of block is transformed into 1 if its intensity value is l greater than the threshold value else takes a value 0 [5].

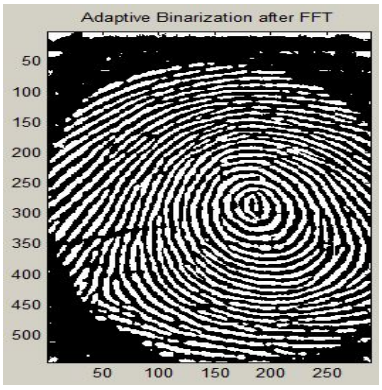

Fig 5: Binarization of fingerprint image

ROI Extraction – Only ROI is useful to be obtained in every fingerprint. A two-step approach process is mainly used to extract the ROI.First one is estimation of image direction and second is to extract ROI using morphological operations.

A. Block Direction Estimation – It involves the calculation of gradient values along x- axis (gx) and y- axis (gy) for the pixel of each block. Then, for each block, least square approximation of the block direction is calculated and finally the insignificant ridges are eliminated or discarded based upon a certainty level of a threshold [7].

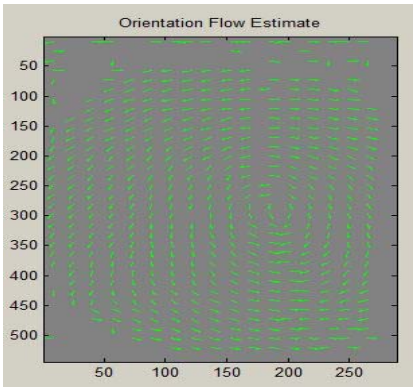

Fig 6: Block Direction estimation

B. By Morphological operations – In this morphological method, OPEN and CLOSE are mainly used. OPEN mainly expand images and removes peak introduced by noise whereas CLOSE usually shrink images and removes small gap. The subtraction of CLOSE from OPEN gives out the ROI. It is shown in Fig.7.

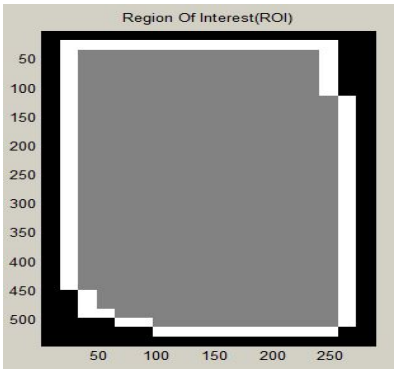

Fig 7: Region of interest (ROI) obtained for Fingerprint

Ridge Thinning – It is the process to eliminate redundant pixels of ridges so as to make one pixel wide ridges. In this, an iterative parallel thinning algorithm is used. In this, it eliminates or turn off the pixels if there is any switch change at the boundary pixels. It is done using a MATLAB morphological function bwmorph (binary Image, 'thin', Inf). In this, some H-breaks and some isolation points are also get removed using imerode () and imfill () MATLAB function. The image thinning process is shown in Fig.8.

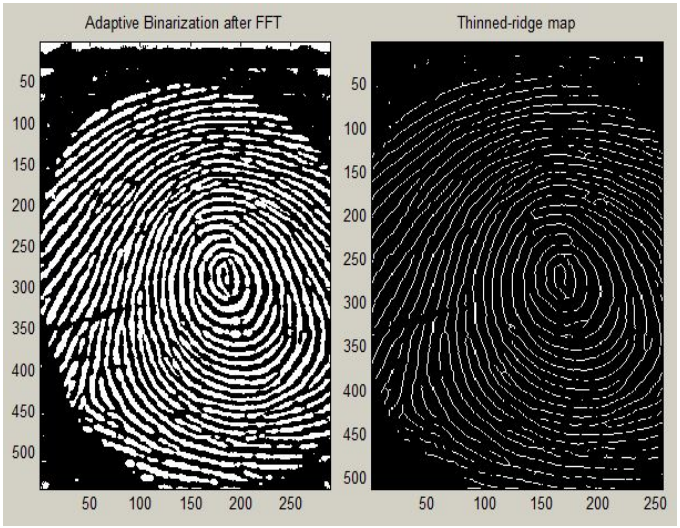

Fig8: Binarized image (left), Thinning image (Right)

Minutia Marking – In this, the concept of crossing number (CN) is used. It is mainly determined by investigating the 8 neighboring pixels of every central pixel (p).It helps to count the occurrences of crossover. In this, if p=1 and there is only 1 one valued pixel as neighboring pixel, then the central pixel is of ridge ending whereas if p=1 and there is exactly 3 one valued pixel, then the central pixel comes under the category of ridge bifurcation.

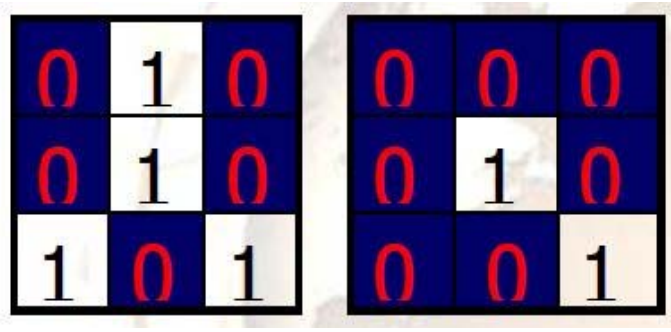

Fig 9: Ridge bifurcation (Left), Ridge ending (Right)

But this above concept of crossing number may lead to generation of false minutiae points as per Fig-10.In this, there is a 4*4 small pixel window, as per according to above algorithm, this will generate three bifurcation points at p1,p2 and p3 instead of one valid bifurcation points. This will ultimately leads to removal of valid bifurcation points which is to be in use during the process of false minutiae removal. Thus, to avoid the removal of valid bifurcation points, we proposed certain changes and following steps.

0	1	0	0
0	1 (p1)	0	0
0	1 (p2)	1 (p3)	1
1	0	0	0

Fig 10: 4*4 pixel window with three bifurcation points

Proposed solution – The main solution to the above problem is that is to detect and delete all the neighboring bifurcation points which are only 1 pixel close to each other. It is done by examining all the neighboring pixels and check if there is more than bifurcation points, if it is there delete it and continue to examine. After the examination, we can proceed with the next step of false minutiae removal to remove rest of false minutiae. We get the following result in Fig.11 after minutia marking.

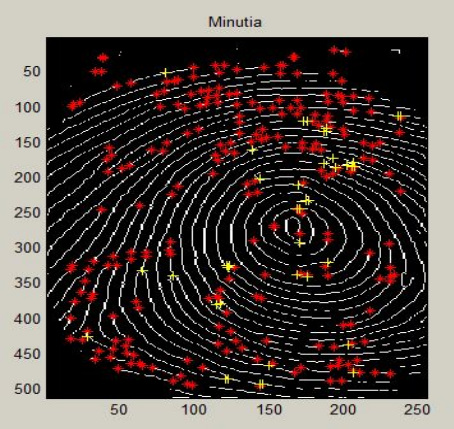

Fig11: Minutiae marking, Ridge ending (Red), Bifurcation (yellow)

False Minutiae Removal – This is the main part in Fingerprint algorithm. Since all the break points which are due to low ink are not completed removed in pre-processing stages and some additional false points are also get added during other steps, thus we need to remove all these false minutia points to obtain an accurate result for verification.

In this process, we firstly calculated the average distance between two neighboring ridges known as Average inter-ridge width (D).This is a part of distance method algorithm. Mainly there are seven types of minutia which are shown in Fig-12

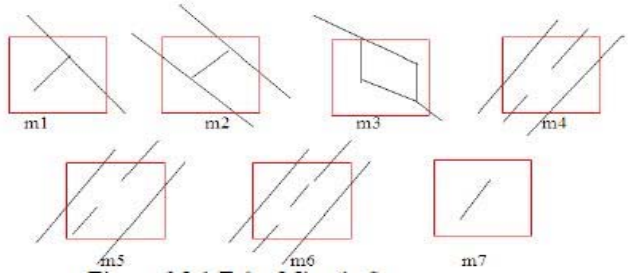

Fig 12: Seven main false minutia structures

Following steps are taken for false minutia removal-

i. If the distance between a bifurcation and ridge ending is less than average inter ridge distance (D) and both minutiae are in same ridge i.e. m1 case, then remove both of them [7].

ii. If the distance between two bifurcations present in the same ridge is less than D, then remove both of them i.e. m2, m3 case.

iii. If two endings are within a distance D and having a same direction with small variation, then it require that no other ridge ending should be present between the two ridge endings. If present, then it is considered to be false minutia and is removed i.e. m4, m5, m6 case.

iv. If two ridge ending are located as short with length less than D, then remove both of them i.e. m7 case

After removing the false minutia points, we get result as per Fig.13.

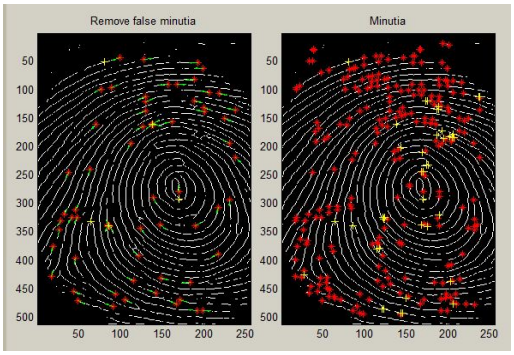

Fig 13: Before removing false minutiae (Right), after removing false minutiae (Left)

Minutia Matching – In this process, as given a two set of fingerprint images, the minutia match will determine whether two minutia sets are from same finger. It is basically done in two stages i.e. Alignment stage and Match stage. In alignment stage, we calculated the similarity between the minutiae of ridge of two images and then if similarity is greater than the threshold, transform each set of minutia to a new coordinate system whose referenced point will be treated as origin. The similarity is calculated with the help of following formula-

$S = \sum xi*Xi / [\sum xi^2*Xi^2] ^{0.5}$ where x and X are set of minutia for each fingerprint image. If the similarity score is greater than 0.8(threshold), then translate and rotate all other minutia with respect with referenced minutia.

In match stage, we normally calculate the final match ratio which is the ratio of total number of matched pairs to the number of minutia of the template fingerprint. Score ranges from 0 to 100.If score is greater than the threshold value, we consider the fingerprint to be matched. The matching process is shown in the following Fig-14

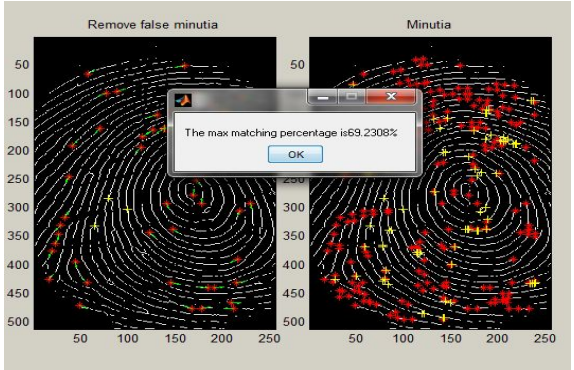

Fig 14: matching percentage of two fingerprints

Conclusion And Future Scope

The main aim for these implementation is to extract reliable minutia points for fingerprint recognition and to improve the efficiency of algorithm of fingerprint recognition. Results shows that we minimized a reliable number of bifurcation points during minutia marking which help us to get a better overall output. We see that the major challenge is to properly enhanced and extract the low quality poor fingerprint images. The above algorithm includes all the stages from loading of image to fingerprint matching concluding as fingerprint an excellent biometric technique.

In future, many more fingerprint algorithm will come which will generate a far better and accurate results. Many approaches like using filters, multigrid subspace approach needs more to be explore.

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