Fingerprint Minutiae Matching using Region of Interest

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***Abstract*— Fingerprint Verification is the most reliable and feasible methods of person identification. The only problem with functionality of Fingerprint Verification System is: it depends on the quality of image. The quality of fingerprint image affects by both environment and scanner's-surface. The Fingerprint Minutiae-Matching is not possible until the quality of fingerprint image improve. The limitation of image processing is that it can only interact with pixel values but not with location of pixels (i.e. Minutiae Points). The only solution to this problem is to select Region of Interest (ROI). In this paper, an effectual Fingerprint Verification System is presented based on ROI. The objective of the research is to study ROI based Fingerprint Minutiae Matching.**

***Keywords*— Fingerprint, Fingerprint Recognition, Histogram Equalization, Binarization, Thinning, Region of Interest, Minutiae Marking.**

I. INTRODUCTION

Biometric is a methods of recognizing a person identification based on their physiological (e.g., fingerprints, face, retina, iris) or behavioural characteristics (e.g., gait, signature, voice). Behavioural characteristics are changed with age but physiological characteristics never changed. Fingerprint recognition is beneficial for all the biometric properties. A number of biometric characteristics are being used in various applications because of its universality, uniqueness, permanence, measurability, performance, acceptability and circumvention [1].

A. What is Fingerprint?

Fingerprints are the most important part in biometric for human identification. They are unique and permanent from birth to death. So, fingerprints have been used for the forensic application and personal identification.

A fingerprint is collection of many ridges and furrows (Valleys). The continuous dark pattern flow in fingerprint is called ridges and the light area between ridges is called furrows. Fingerprint has some unique points on the ridge which is known as minutiae point. In this paper we can consider two main types of minutiae points which are termination point and bifurcation point as shown in Fig.1. Termination: where a ridge ends and Bifurcation: where ridges split into two parts.

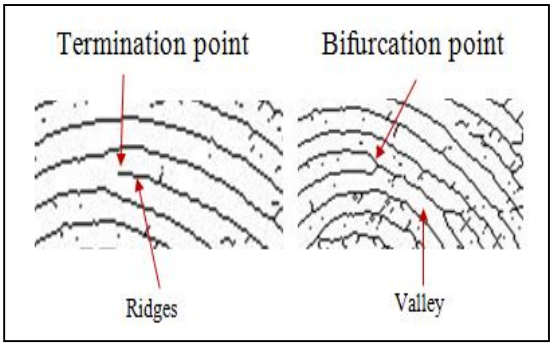

Fig. 1 Minutiae Points (Termination, Bifurcation)

B. Fingerprint Recognition

Fingerprint Recognition can be categorized into two sub-domains: that is fingerprint verification and fingerprint identification. Fingerprint verification is also called one-to-one matching. In this method we compare a prosecutor fingerprint with an enrolee fingerprint, where we match both the fingerprints. This method is used to verify a person's authenticity. Fingerprint identification is also called one-to-many matching. It is mainly used to specify any person's identity by his fingerprint. This method is traditionally used for solve crime and catch thieves.

C. Techniques for Fingerprint Recognition

1) *Minutiae Extraction based Techniques*: Mostly accepted finger scan technology is based on Minutiae. Minutiae based techniques produce the fingerprint by its local features, like termination and bifurcation. When minutiae points match between two fingerprints so fingerprint are match. This approach has been genuinely studied, and it is the backbone of the current available fingerprint recognition products.

2) Pattern Matching or Ridge Feature based Techniques: Feature extraction are established on series of ridges as averse to different points which design the basis of pattern matching techniques over Minutiae Extraction. Minutiae points can be change by wear and tear and the main drawback are that these

are acute to proper adjustment of finger and need large storage for templates.

3) Correlation based Techniques: Correlation based technique is used to match two fingerprints, the fingerprint are adjusted and computed the correlation for each corresponding pixel. They can match ridge shapes, breaks, etc. Main disadvantages of this method are its computational complication and less tolerance to non-linear distortion and contrast variation.

4) *Image based Techniques:* This technique attempt to do matching which based on the global features of an all fingerprint images. It is an advance and newly develops method for fingerprint recognition [1] [2] [3].

II. Fingerprint Matching

The matching of fingerprint is achieved by some image processing steps. These step can easily be understand by the algorithm below:

Input: Two Gray-scale Fingerprint image.

Output: Verify the fingerprint image using minutiae matching.

Step 1: Enhancement of Input Image i.e. fingerprint image using Histogram equalization.

Step 2: Binarized the enhanced fingerprint image.

Step 3: Selection of ROI (Region of Interest) in binarized image.

Step 4: Thinning of the Region of Interest as the part of fingerprint image.

Step 5: Minutiae points are extracted from image.

Step 6: Comparison and matching of one fingerprint to another fingerprint.

Step 7: Match the minutiae points of two images are computed. If Minutiae points are matched in both images so fingerprint matching score are 1 and if it is not matched then matching score are 0 they are mismatched.

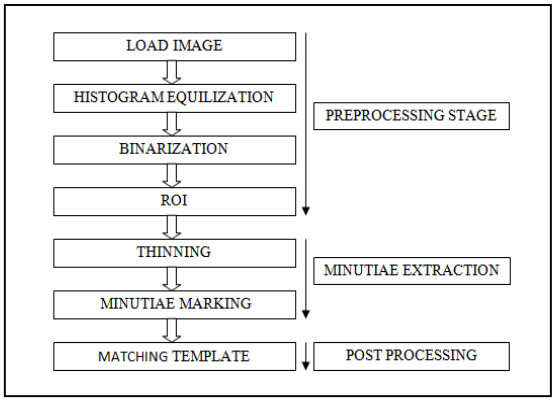

Fig. 2 Fingerprint Matching block diagram

The overall implementation of algorithm may also express by using block diagram, as shown above. This block diagram is sub divided as pre-processing stage, minutiae extraction stage and post-processing stage [2].

III. Pre-processing Stage

A. Histogram Equalization

It is a method for enhance the fingerprint image. Fingerprint image enhancement is to create clearer for easy other operations. Histogram equalization is to extend the pixel value of an image so as to increase the perceptional information. The histogram of a original fingerprint image has the bimodal type [fig 4.1], the histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced. The general histogram equalization formula is:

$$h(w) = round\left(\frac{cdf(w) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L-1)\right)$$

Where cdf_{min} is the minimum value of the cumulative distribution function, M × N gives the image's number of pixels and L is the number of grey levels. In MATLAB histogram equalization is done by using MATLAB function.

histeq (image_file_name);

Below, the figure shows the original image histogram and histogram after equalization operation [5].

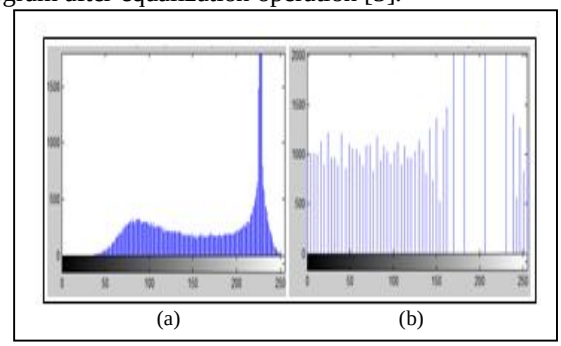

Fig. 3 (a) Original Histogram, (b) Histogram after Equalization

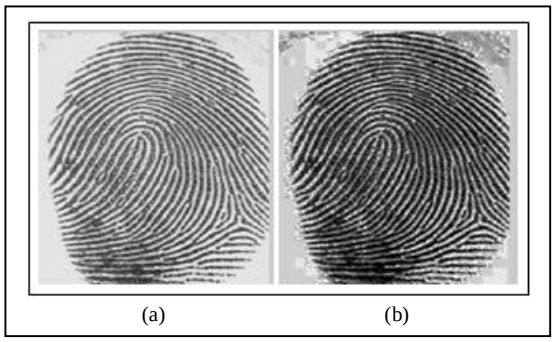

Fig. 4 (a) Original Image (b) Enhanced Image after Equalization

B. Binarization

A Fingerprint-Image-Binarization transforms an 8-bit gray image to a 1-bit binarized image where 0-value holds for ridges and 1-value for furrows. And after the binarization operation ridges are highlighted with black color and furrows are highlighted with white color.

An adaptive binarization method is achieved to binarize the fingerprint image. In this method image is split into blocks of 16 x 16 pixels. A pixel value is set 1 if its value is greater than

the mean intensity value of the accepted block to which the pixel belongs (Fig. 5) [6].

Fig. 2 Fingerprint Matching block diagram

C. Region of Interest (ROI)

This is a segmentation technique. The main motive of the segmentation is to make the image simpler which can be representing very easily and to make image meaningful that will be easy to analyze. Generally ROI (Region of Interest) is very useful for analyze a fingerprint image. It is a subset of an image or a dataset analyze for a particular purpose. When the image area has ineffective ridges and furrows so firstly it made wider and larger in all directions. To extraction of the ROI is performed in two steps: First, block direction estimation and direction variety check; Second, used some Morphological methods.

Two types of morphological methods are available i.e. OPEN and CLOSE. The OPEN operation can enlarge the images and eliminate background noise. And CLOSE operation can shrink images and eliminate small cavities [4].

bwmorph (x, "close");
bwmorph (y, "open");

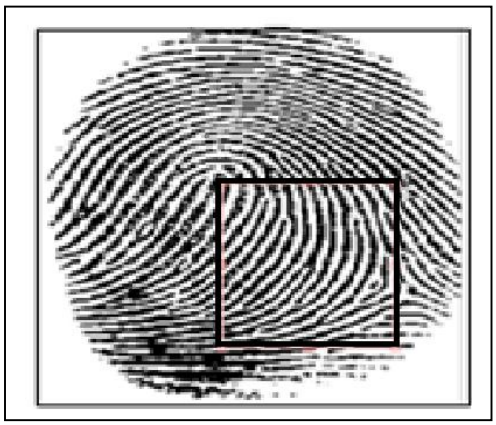

Fig. 6 Selection of Region of Interest

IV. Minutiae Extraction Stage

Email address is compulsory for the corresponding author.

A. Thinning

The ridge thinning process in used to remove the redundant pixels and reduce the thickness of ridges till the one pixel wide. This is done by using the MATLAB"s thinning function that is-

bwmorph (binary Image, "thin", Inf);

Then the thinned image is filtered by using the following three MATLAB"s functions. This is used to remove some H breaks, isolated points and spikes.

bwmorph (binary Image, "hbreak", k);
bwmorph (binary Image, "clean', k);
bwmorph (binary Image, "spur', k);

The thinned fingerprint image contained single pixel width and discontinuities. The conditions for better thinning result:

a) Each ridge should be thinned to its centre pixel.
b) Noise and singular pixels should be removed.
c) No further removal of pixels should be possible after accomplish of thinning process [2].

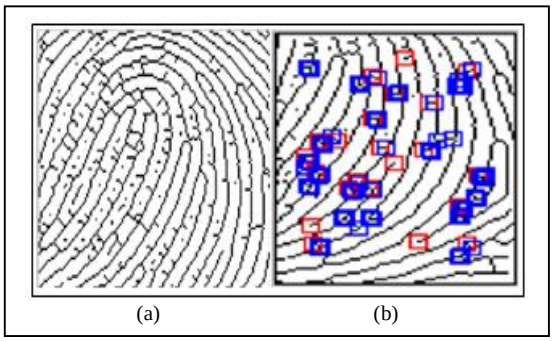

Fig. 7 (a) Thinned Image, (b) Extracted Minutiae in ROI

B. Minutiae Marking

After fingerprint ridge thinning process, a minutia marking is done by using 3 X 3 pixel windows. In minutiae marking the concept of Crossing Number (CN) is mainly used. In 3 X 3 pixel window if the central pixel is 0 and has only 1 one-value neighbour, then the central pixel is a ridge ending and if the central pixel is 1 and has exactly 3 one-value neighbours, then the central pixel is a ridge branch or bifurcation [4].

Cn{p} =1 Ridge Ending
Cn{p} =3 Ridge Bifurcation

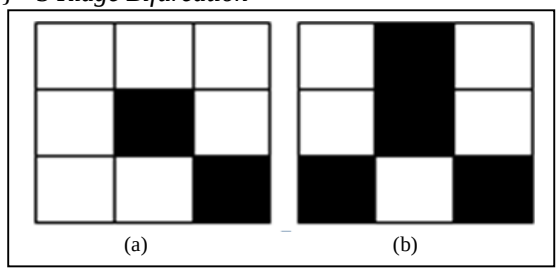

Fig. 8 (a) Ridge Ending, (b) Ridge Bifurcation

V. Post-Processing Stage

A. Minutiae Matching

When all minutiae points of two fingerprint images are extracted in selected region of interest. Now, minutiae matching are performed for verification. Basically, minutiae matching are a process which completed in two steps:

1) *Find Total Minutia Points*: This step is used to calculate the total number of Ridge and Bifurcation points separately.

And it compare the calculate value with the original image values.

2) Find Location of Minutiae Points: It works on the basis of Minutia Marking process. Simply, when minutia points marked on the image it also store the location of the point. This stored information it used to compare two different images at verification process. If both the images belongs to the same person then the location of ridge/bifurcation will match. Otherwise, matching of fingerprint images unsuccessful.

VI. CONCLUSIONS

This paper suggests a prototype which is robust and secure for Fingerprint Matching. This paper has two important operations in pre-processing stage as Histogram Equalization, and Selection of ROI. These two operations make this algorithm efficient. The Histogram Equalization enhanced the quality of Input-image, which actually help to produce accurate calculation. This research concludes that the Fingerprint Verification is possible even the quality of the fingerprint image got affected. The ROI based approach reduces the processing time of algorithm by working on segment not the complete image, which means it makes fingerprint matching faster. The verification is done for selected region that authenticate the pattern. The literature of this technique is deeply studied and experimentally executed in MATLAB.

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