

A Hybrid Algorithm for Fingerprint Recognition System

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Abstract—The increase in use of automated fingerprint recognition puts on it a challenge of processing a diverse range of fingerprints. To make it supportive in consisting fingerprint detail extraction, quality control is required, which is used in identification/verification. Fingerprint verification is one of the most reliable personal identification methods and it plays a very important role in forensic applications like criminal investigations, terrorist identification and National security issues. Some fingerprint identification algorithm (such as using Fast Fourier Transform (FFT), Minutiae Extraction) may require so much computation as to be impractical. Because quality of fingerprints varies according to the user population's ages and fingerprint quality has an impact on overall system performance, it is important to understand the significance of fingerprint samples from different age groups.

Keywords— *Minutia, cross-correlation, Otsu's binarization, FFT.*

I. INTRODUCTION

Nowadays, fingerprint recognition is one of the most important biometric technologies based on fingerprint distinctiveness, persistence and ease of acquisition. Although there are many real applications using this technology, its problems are still not fully solved, especially in poor quality fingerprint images and when low-cost acquisition devices with small area are adopted. In fingerprint recognition process, the important step which affects on system accuracy is matching between template and query fingerprint. Many solutions are designed to increase this step's accuracy ([1], [2], [5], [6], [7], [9]). These matching algorithms may be classified into three types: minutiae-based approach, correlation-based approach and feature-based approach. However, as [9] analyzed, the score of these algorithms is not high (especially in case fingerprints are of the same finger but they are rotated or the intersection is too small). So, it's necessary to design a model to standardized fingerprint template in order to improve matching score. In an increasingly digitized world the reliable personal authentication has become an important human computer interface activity. National security, e-commerce and access to computer networks are now very common where establishing a person's identity has become vital.

Existing security measures rely on knowledge-based approaches like passwords or token-based approaches such as swipe cards and passports to control access to physical and virtual spaces, but these methods are not very secure. Tokens such as badges and access cards may be duplicated or stolen. Passwords and personal identification number (PIN) numbers may be stolen electronically. Biometrics such as fingerprint, face and voice print offers means of reliable personal authentication that can address these problems and is gaining citizen and government acceptance. Biometrics is a rapidly evolving technology which uniquely identifies a person based on his/her physiological or behavioral characteristics such as finger prints, hand geometry, iris, retina, face, hand vein, facial thermo grams and voice print [1]. It relies on "something that you are" to make personal identification and therefore can inherently differentiate between an authorized person and a fraudulent impostor. Although biometrics cannot be used to establish an absolute "yes/no" personal identification like some of the traditional technologies, it can be used to achieve a "positive identification" with a very high level of confidence, such as an error rate of 0.001% [2]. Several studies show that the biometric authentication system based on recognizing the unimodal biometric template suffer from insufficient accuracy caused by noisy data, limited degrees of freedom, non-distinctive and non-universal biometric traits and performance limitations [3,4]. Among all biometric indicators, finger prints have one of the highest level of reliability [5] [6] and have been extensively used by forensic experts in criminal investigations [7]. A fingerprint image is a pattern of ridges and valleys, with ridges as dark lines while valleys as light areas between the ridges. Ridges and valleys generally run parallel to each other, and their patterns can be analyzed on a global and local level. The ridge structure in a fingerprint can be viewed as an oriented texture patterns having a dominant spatial frequency and orientation in local neighborhood. The frequency is due to inter ridge spacing and orientation is due to the flow pattern exhibited by ridges. So a finger print can be viewed as an oriented texture pattern. Jain et al. showed that for sufficiently complex oriented texture such as finger prints, invariant texture representations can be extracted by combining both global and local discriminating information in the texture [8].

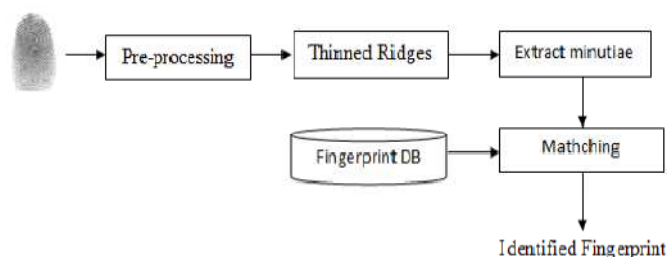


Fig 1. Fingerprint Recognition process

II. RELATED WORK

Jian-De Zheng et al. [10] introduced fingerprint matching based on minutiae. The proposed algorithm uses a method of similar vector triangle. The ridge end points are considered as the reference points. Using the reference points the vector triangles are constructed. The fingerprint matching is performed by comparing the vector triangles. S.D.Sawarkar et.al. [11] focused on a reliable method of computation for minutiae feature extraction from fingerprint images. A fingerprint image is treated as a textured image. Improved algorithms for enhancement of fingerprint images, which have the adaptive normalization based on block processing, are proposed. An orientation flow field of the ridges is computed for the fingerprint image. To accurately locate ridges, a ridge orientation based computation method is used. After ridge segmentation a method of computation is used for smoothing the ridges. The ridge skeleton image is obtained and then smoothed using morphological operators to detect the features. A post processing stage eliminates a large number of false features from the detected set of minutiae features algorithm. Ishmael S. Msiza, et. al. [12]; showed the problem of Automatic Fingerprint Pattern Classification (AFPC) which is being studied by many fingerprint biometric practitioners. It is an important concept because, in instances where a relatively large database is being queried for the purposes of fingerprint matching, it serves to reduce the duration of the query. The fingerprint classes discussed in this document are the Central Twins, Tented Arch, Left Loop, Right Loop and the Plain Arch. The classification rules employed in this problem involve the use of the coordinate geometry of the detected singular points. Zhang quinghui and Zhang Xiangfie [13] proposed the algorithm for fingerprint Identification.

Fingerprint image pretreatment processes like gamma controller standardization, Directional diagram computation, image filtering, binarization processes and image division were applied for improving the image quality. K. Thaiyalnayaki, S. Syed Abdul Karim, P. Varsha Parmar [14] introduced a fingerprint recognition system using texture analysis to overcome the problem of minutiae based techniques with an effective combination of features for multi-scale and multi-directional recognition. The features include standard deviation, kurtosis, and skewness. The most common approach for fingerprint analysis is using minutiae that identifies corresponding features and evaluates the resemblance between two fingerprint impressions. Minutiae based techniques suffer from false, missed, and displaced minutiae, caused by poor fingerprint image quality and imperfections in the minutiae extraction stage. Avinash Pokhriyal, Sushma Lehri [15] proposed an approach for fingerprint verification based on wavelets and Pseudo Zernike Moments (PZMs) to extract global and local features. PZMs are robust to noisy images, invariant to rotation and have a good image reconstruction capability making it useful for global analysis and to global features (the shape of the fingerprint image) extraction. Wavelets are good at local analysis and so they help to extract local features (minutiae) from a fingerprint. Therefore, this hybrid approach extracts most significant features from the fingerprint images and achieve better verification rate.

III. FINGERPRINT MATCHING TECHNIQUES

The large number of approaches to fingerprint matching can be coarsely classified into three families.

- **Correlation-based matching:** Two fingerprint images are superimposed and the correlation between corresponding pixels is computed for different alignments (e.g. various displacements and rotations).
- **Minutiae-based matching:** This is the most popular and widely used technique, being the basis of the fingerprint comparison made by fingerprint examiners. Minutiae are extracted from the two fingerprints and stored as sets of points in the two-dimensional plane. Minutiae-based matching essentially consists of finding the alignment between the template and the input minutiae sets that results in the maximum number of minutiae pairings
- **Pattern-based (or image-based) matching:** Pattern based algorithms compare the basic fingerprint patterns (arch, whorl,

and loop) between a previously stored template and a candidate fingerprint. This requires that the images be aligned in the same orientation. To do this, the algorithm finds a central point in the fingerprint image and centers on that. In a pattern-based algorithm, the template contains the type, size, and orientation of patterns within the aligned fingerprint image. The candidate fingerprint image is graphically compared with the template to determine the degree to which they match.

IV. IMPLEMENTATION

The first step in the minutiae extraction stage is Fingerprint Image enhancement. This is mainly done to improve the image quality and to make it clearer for further operations. Often fingerprint images from various sources lack sufficient contrast and clarity. Hence image enhancement is necessary and a major challenge in all fingerprint techniques to improve the accuracy of matching. It increases the contrast between ridges and furrows and connects the some of the false broken points of ridges due to insufficient amount of ink or poor quality of sensor input.

Fingerprint Image Enhancement

The first step in the pre-processing stage is fingerprint image enhancement. Fingerprint image enhancement is to make the image quality and clearer image for easy further operations. Often, fingerprint images from various sources lack sufficient contrast and clarity. Hence, image enhancement is necessary and a major challenge in all fingerprint techniques to improve the accuracy of matching. Since, the fingerprint images acquired from sensors or other medias are not assured with perfect quality, those enhancement methods, for increasing the contrast between ridges and furrows and for connecting the false broken points of ridges due to insufficient amount of ink, are very useful for keep a higher accuracy to fingerprint recognition.

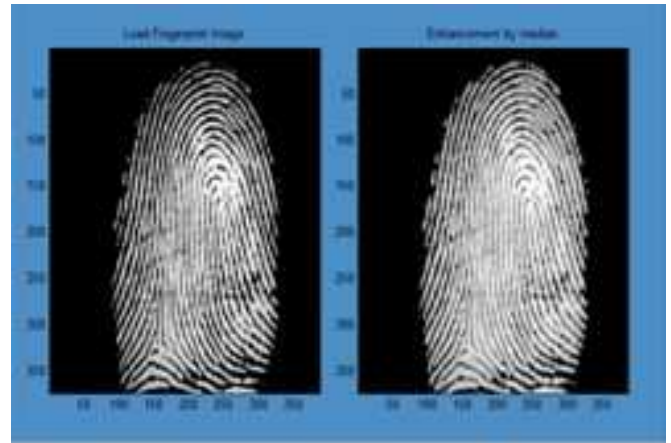


Figure 2 (left: original image, right: enhanced image)

In the figure 2 the image is filtered using the median filter. Median filter is a filter that can be used in all type of noise, but it can't give the best results in all the cases. The above filter reduces the nose to some extent and can be applied to additive noise.

Fast Fourier Transformation: In this method the image is divided into small processing blocks (32 x 32 pixels) and perform the Fourier transform according to equation:

$$F(u, v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \times \exp \left\{ -j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N} \right) \right\} \quad (1)$$

for u = 0, 1, 2, ..., 31 and v = 0, 1, 2, ..., 31.

In order to enhance a specific block by its dominant frequencies, we multiply the FFT of the block by its magnitude a set of times. Where the magnitude of the original FFT = abs (F (u, v)) = |F (u, v)|.

So we get the enhanced block according to the equation:

$$g(x, y) = F^{-1} \left\{ F(u, v) \times |F(u, v)|^k \right\} \quad (2)$$

where $F^{-1}(F(u, v))$ is given by:

$$f(x, y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u, v) \times \exp \left\{ j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N} \right) \right\} \quad (3)$$

For x = 0, 1, 2 ...31 and y = 0, 1, 2 ...31.

Figure 3 presents the image after FFT enhancement.

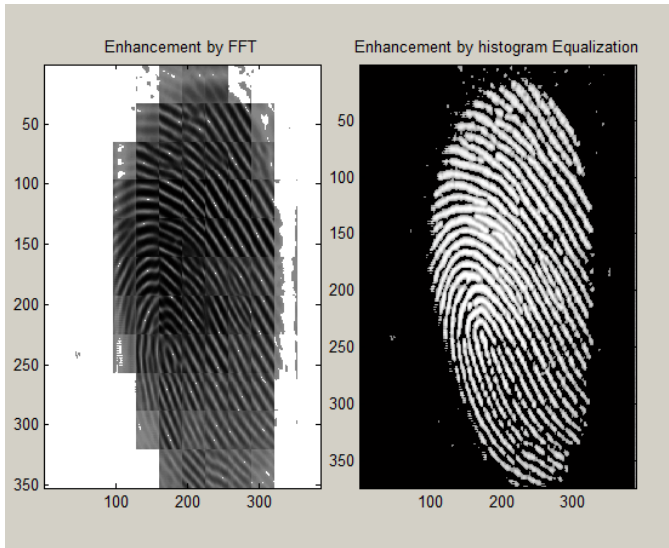


Fig 3. FFT Enhancement

Image Binarization

Image Binarization is a process which transforms the 8-bit Gray image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white. In this process the Ostu’s binarization is used to make this process realistic.

In this method image is divided into blocks of 16 x 16 pixels iteratively. A pixel value is then set to 1 if its value is larger than the mean intensity value of the current block to which the pixel belongs to Fig 4.

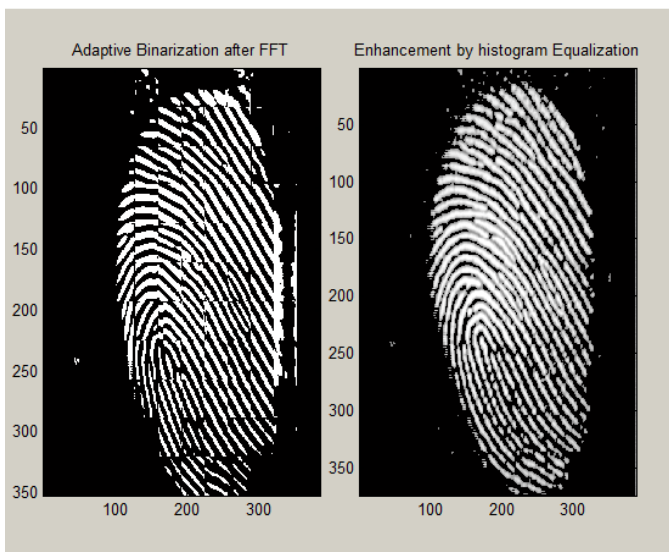


Fig 4. Binarization

Fingerprint Image Segmentation

After image enhancement the next step is fingerprint image segmentation. In general, only a Region of Interest (ROI) is useful to be recognized for each fingerprint image. The image area without effective ridges and furrows is first discarded since it only holds background information. Then the bound of the remaining effective area is sketched out since the minutiae in the bound region are confusing with those spurious minutiae that are generated when the ridges are out of the sensor.

ROI Extraction by Morphological operations

ROI extraction is done using two Morphological operations called OPEN and CLOSE. The OPEN operation can expand images and remove peaks introduced by background noise (Figure 3.6). The ‘CLOSE’ operation can shrink images and eliminate small cavities.

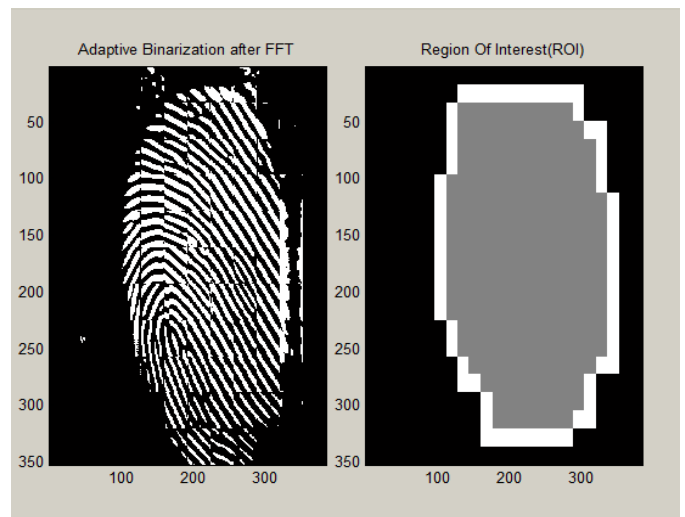


Fig 5. ROI Area

Final Minutiae Extraction

Now that we have enhanced the image and segmented the required area, the job of minutiae extraction closes down to four operations: Ridge Thinning, Minutiae Marking, False Minutiae Removal and Minutiae Representation.

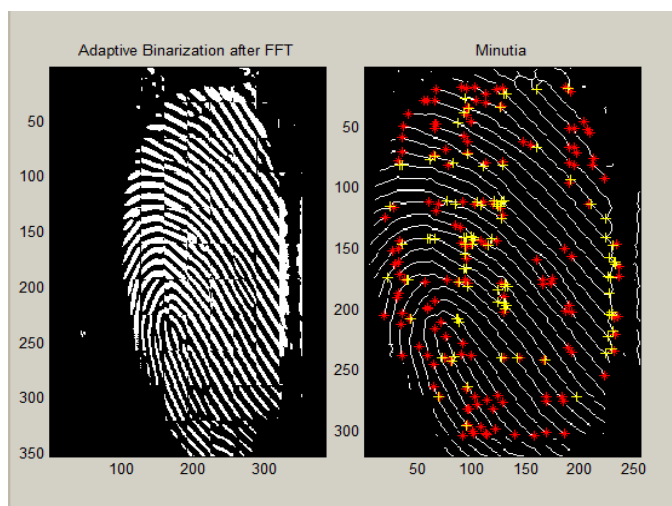


Fig 6. Minutiae Extraction

Minutiae Matching

After successfully extracting the set of minutia points of 2 fingerprint images to be tested, we perform Minutiae Matching to check whether they belong to the same person or not. We use an iterative ridge alignment algorithm to first align one set of minutiae w.r.t other set and then carry-out an elastic match algorithm to count the number of matched minutia pairs.

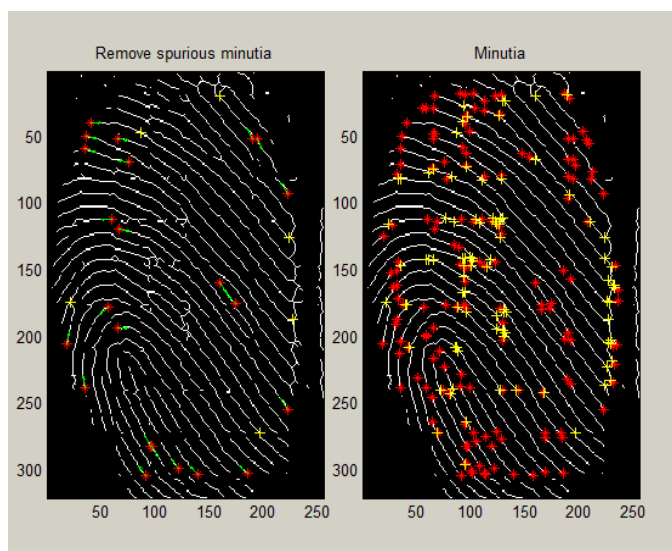


Fig 7. Minutiae matching

V. CONCLUSION

The above implementation is an effort to understand how Fingerprint Recognition is used as a form of biometric to recognize identities of human beings. It includes all the stages from minutiae extraction from fingerprints to minutiae matching which generates a match score. Various standard techniques are used in the intermediate stages of processing. The binarization techniques used in this system is Otsu's binarization method, which enhanced the accuracy of the system. Using the Otsu's binarization technique the binarization method is improved as the image is divided into two states and the noise in the image is removed which results into enhancement in extraction of the features. The relatively low percentage of verification rate as compared to other forms of biometrics indicates that the algorithm used is not very robust and is vulnerable to effects like scaling and elastic deformations. Various new techniques and algorithm have been found out which give better results.

VI. REFERENCES

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