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Splitting for ROI for Finger Print Recognition Using MATLab

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Abstract—This paper is a study and implementation of a fingerprint recognition system based on Minutiae based matching quite frequently used in various fingerprint algorithms and techniques. The approach mainly involves extraction of minutiae points from the sample fingerprint images and then performing fingerprint matching based on the number of minutiae pairings among two fingerprints in question.

Keywords- Image Segmentation; Minutiae; fingerprint, MATLAB, etc.

My implementation mainly incorporates image enhancement, image segmentation, feature (minutiae) extraction and minutiae matching. It finally generates a percent score which tells whether two fingerprints match or not. The project is coded in MATLAB Introduction

I. INTRODUCTION

Fingerprint recognition [1][2][16] or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify an individual and verify their identity. Because of their uniqueness and consistency [1] over time, fingerprints have been used for over a century, more recently becoming automated (i.e. a biometric) due to advancement in computing capabilities [2].

A. What is Finger Print?:

A fingerprint is the feature pattern of one finger (Figure 1.1). It is an impression of the friction ridges and furrows on all parts of a finger. These ridges and furrows present good similarities in each small local window, like parallelism [2] and average width.

Figure 1.1 Fingerprint image from a sensor

However, shown by intensive research on fingerprint recognition, fingerprints are not distinguished by their ridges and furrows, but by features called Minutia [7], which are some abnormal points on the ridges (Figure 1.2). Among the variety of minutia types reported in literatures [5], two are mostly significant and in heavy usage:

(a) Ridge ending - the abrupt end of a ridge
(b) Ridge bifurcation - a single ridge that divides into two ridges.

(a) (b)

Figure 1.2(a) two important minutia features (b) Other minutiae features

a. What is Fingerprint Recognition?:

Fingerprint recognition [1] (sometimes referred to as dactyloscopy) is the process of comparing questioned and known fingerprint against another fingerprint to determine if the impressions are from the same finger or palm. It includes two sub-domains: one is fingerprint verification [13] and the other is fingerprint identification [6] (Figure 1.3).

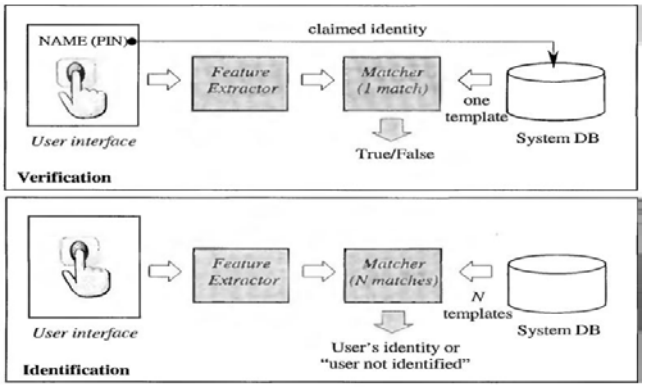
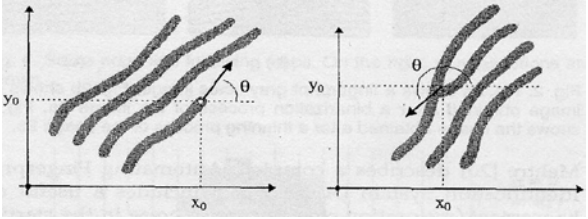


Figure 1.3 Verification vs. Identification

In addition, different from the manual approach for fingerprint recognition [1][2] by experts, the fingerprint recognition here is referred as AFRS[11] (Automatic Fingerprint Recognition System), which is program-based.

II. IMPLEMENTATION

I have concentrated our implementation on Minutiae based method [7][8][9]. In particular I am interested only in two of the most important minutia features i.e. Ridge Ending and Ridge bifurcation [16]. (Figure 2.1)



(a) (b)

Figure 2.1(a) Ridge Ending, (b) Ridge Bifurcation

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The outline of our approach can be broadly classified into 2 stages - Minutiae Extraction and Minutiae matching.

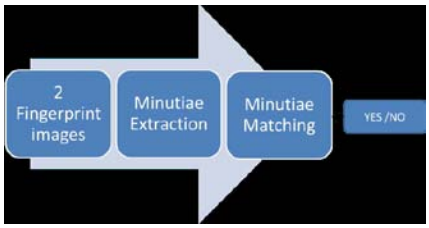

Figure 2.2 System Flow Diagram

Figure 2.2 illustrates the flow diagram of the same. The system takes in 2 input fingerprints to be matched and gives a percentage score of the extent of match between the two. Based on the score and threshold [10] match value it can distinguish whether the two fingerprints match or not. The input fingerprints are taken from the database provided by FVC2004 (Fingerprint Verification Competition 2004) [4].

A. Design Description:

The above system is further classified into various modules and sub-modules as given in Figure 2.3.

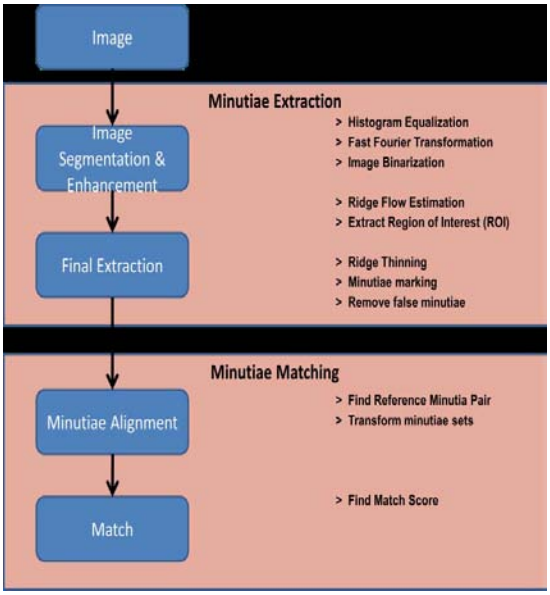

Figure 2.3 Detailed Design Description

Minutia extraction [7][9] includes Image Enhancement, Image Segmentation and Final Extraction processes while Minutiae matching include Minutiae Alignment and Match processes. Under image enhancement step Histogram Equalization, Fast Fourier Transformation increases the quality of the input image and Image Binarization converts the grey scale image to a binary image. Then image segmentation is performed which extracts a Region of Interest using Ridge Flow Estimation and MATLAB's morphological functions. Thereafter the minutia points are extracted in the Final Extraction step by Ridge Thinning [12], Minutia Marking and Removal of False Minutiae processes. Using the above Minutia Extraction process I get the Minutiae sets for the two fingerprints to be matched. Minutiae Matching process iteratively chooses any two minutiae as a reference minutia pair and then matches their associated ridges first. If the ridges match well, two fingerprint images are aligned and matching is conducted for all remaining minutia to generate a Match Score[9].

III. MINUTIAE EXTRACTION

As described earlier the Minutiae extraction [7][8] process includes image enhancement, image segmentation and final Minutiae extraction.

A. Fingerprint Image Enhancement:

The first step in the minutiae extraction [7][8] stage is Fingerprint Image enhancement. This is mainly done to improve the image quality and to make it clearer for further operations.

B. Histogram Equalization:

Histogram equalization is a technique of improving the global contrast of an image by adjusting the intensity distribution [14] on a histogram. This allows areas of lower local contrast to gain a higher contrast without affecting the global contrast.

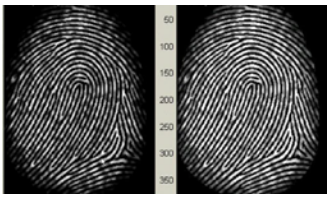

Figure 3.2(a) Original Image, (b) Enhanced Image after histogram equalization

IV. FINGERPRINT IMAGE SEGMENTATION FOR ROI

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.

To extract the region of interest, two steps are followed: Block direction estimation and ROI extraction by Morphological methods.

A. Region Based Segmentation:

Let R represent the entire image.
I can view segmentation as a process that partitions R into sub – regions R_1, R_2, ... R_n such that

a. $_{i=0}U^{n} R_i = R$
b. R_i is a connected region, i= 1, 2, …..n.
c. $R_i \cap R_j = \varphi$ for all i and j; $i \neq j$
d. $P(R_i) =$ True for i= 1, 2,….n.
e. $P(R_i \cup R_j) =$ False for $i \neq j$

Where $P(R_i)$ is the logical predicate over the points in the set R and φ is the null set.

The five conditions stated can be interpreted as follows:

(a) The union (sum) of all the regions equals the whole image. In other words all pixels in the image must be assigned to a region.
(b) Each region is continuous and connected, (it could be better 4-connectivity or 8- connectivity or m-connectivity).

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(c) The interaction of any pair of adjacent regions equals the empty set. i.e., each pixel belongs to a single region only and hence there is no overlap between regions.
(d) For each region, the uniformity predicate is true. Each region must satisfy some particular uniformity condition
(e) For any two adjacent regions, the uniformity predicate is false. It simply means two adjacent regions do not anything in common.

B. Region Splitting and Merging:

The main goal of region splitting and merging is to distinguish the homogeneity of the image [5]. Its concept is based on quadtrees, which means each node of trees has four descendants and the root of the tree corresponds to the entire image. Besides, each node represents the subdivision of a node into four descendant nodes, only *R*4 was subdivided fur-there. The basics of splitting and merging are discussed below.

Let *R* represent the entire image region and decide a predicate *P*. The purpose is that if P(R) = FALSE, I divide the image *R* into quadrants.

If *P* is FALSE for any quadrant, I subdivide that quadrant into sub quadrants, and so on. Until that, for any region *Ri*, = TRUE. After the process of splitting, merging process is to merge two adjacent regions *Rj* and *Rk* if P (R_J U R_K). The Procedure is as follows:

Step1. Splitting steps: For any region *Ri*, which P (R_i) = FALSE, I split it into four disjoint quadrants.

Step2. Merging steps: When no further splitting is possible, merge any adjacent regions Rj and Rk for which P (R_J U R_K) = TRUE.

Step3. Stop only if no further merging is possible.

I conclude the advantages and disadvantages of region splitting and merging:

C. Homogeneity condition::

Max{ g(x,y)} – Min { g(x,y)} <= threshold (x, y $\in$ R_1)

If this property is true there is no need for further splitting.

V. CONCLUSION

The above implementation was an effort to understand how Fingerprint Recognition [1][16]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.

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