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A Survey on Fingerprint Minutiae Extraction

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Abstract: ***The modern world is fully computerized and now it has become more and more important to authenticate people in a secure way. Current applications like online banking or online shopping use techniques that depend on personal identification numbers, keys, or passwords. In this paper, we have surveyed on various minutiae extraction techniques.***

Keywords: Fingerprint, Minutiae, Ridge Termination, Bifurcation, Binarization, Crossing Number, Thinning etc.

INTRODUCTION

The biometric word is made from the two Greek words *bios which mean life* and metrics which mean measure [7]. Humans make use of some its body characteristics such as face, eyes, hand, finger, iris, gait, or voice to recognize each other. Biometrics cannot be borrowed, stolen, or forgotten [5].

Biometrics is the study of distinctively recognizing humans based upon one or more intrinsic physical or behavioral traits. Fingerprints are the most broadly used parameter for personal detection amongst all biometrics [9] [10][1]. Fingerprint identification is frequently engaged in forensic science to aid criminal investigations etc. A fingerprint is a unique pattern of ridges and valleys on the surface of a finger of an individual [2]. The accuracy of the technique is dependent upon the precision of the extraction of minutiae. [8]

TYPES OF FINGERPRINT TECHNIQUES

Fingerprint classification identifies and categorizes various fingerprints. Various unique identification points such as e.g. island, ridge end, core, and delta exist in a fingerprint.

Usually, fingerprint classification is categories into the following six classes:

i) whorl, ii) right loop, iii) left the loop, IV) arch, v) twin loop, and VI) tented arch [2].

It also contains one or more regions where the ridge lines make different shapes curvature, termination, etc.). These regions are called singularities or singular regions may also be classified into three typologies: loop, delta, and whorl.

Relatively low costs make it an affordable, simple choice for workplace access security. Fingerprint identification is the oldest method among all the biometric techniques and has been used in various applications [6].

Fig. 1 Minutiae Points. (a) Ridge ending (b) bifurcation

Ridge Feature Based Technique or Pattern Matching

Feature extraction and template generation are based on series of ridges as opposed to discrete points which form the basis of Ridge Feature Based Technique. A matching using the ridge feature in form of finger code consists of computing the difference of two finger code vectors (query and reference). However, before applying the finger code, it is important to align the fingerprint images, which is really a big problem, as in the case of other methods. In some cases, the singularity may be used for that purpose. A finger code also may be used as a complementary to the minutia based method in order to improve the overall matching accuracy. The original approach of this method used circular finger codes, considering as center the core point. The final result of the finger code difference is normalized and averaged using the eight directions and obtained a value that varies from 0 to 1. The lower the score, the more similar are the fingerprints. Some threshold values are used to decide whether there is matching or not.

Correlation Based Technique

In order to match two fingerprints using the correlation based technique, the fingerprints are aligned and the correlation is computed for each corresponding pixels, however, as the displacement and rotation are unknown it is necessary to apply the correlation for all possible alignments. The singularity information may be useful in order to find an approximated alignment. The main drawback of this method is its computational complexity and less tolerance to non-linear distortion and contrast variation. There have been some alternative proposals that compute the correlation locally instead of globally, in which only interesting regions (e.g., minutia and singularity regions) are selected and matched. These algorithms use simple techniques to align two fingerprint images and subtract the input image from the template image to see if the ridges correspond.

Minutiae Based Technique:

The majority of the Fingerprint Identification techniques are based on Minutiae. The points where the ridge lines terminate or fork are called Minutiae [7] whereas according to Galton, each ridge is characterized by numerous minute peculiarities called Minutiae. Many types of minutiae exist, including dots (very small ridges), islands (ridges slightly longer than dots, occupying a middle space between two temporarily divergent ridges), ponds or lakes (empty spaces between two temporarily divergent ridges), spurs (a notch protruding from a ridge), bridges (small ridges joining two longer adjacent ridges), and crossovers (two ridges which cross each other). Two fingerprints match if their minutiae are matched [5].

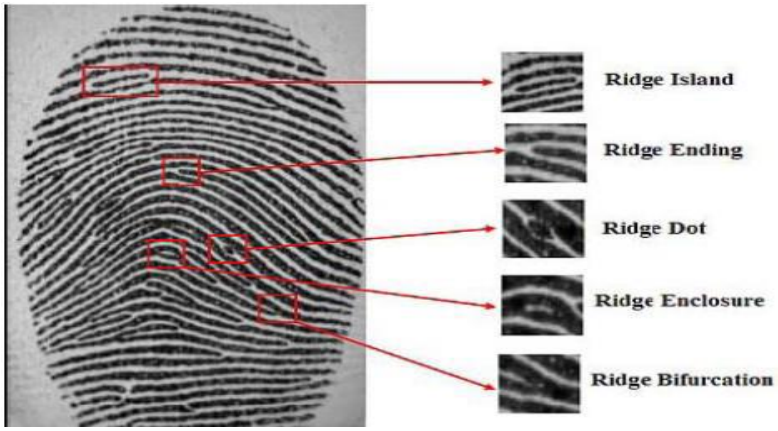

Fig. 2 some common minutiae patterns

STEPS INVOLVED IN MINUTIAE EXTRACTION

Steps to extract minutiae as a feature are as following:

1. ***Binarization***

Binarization is the method of transforming a gray scale image into a black and white image (or binary image). In MATLAB, a value of one represents that the pixel is white and value of zero represents that the pixel is black. This modification of gray scale image to binary image is executed by using threshold process to the image. When we apply threshold process to an image, each pixel values can be analyzed to the input threshold. Those pixel values which are smaller than the threshold value place to zero and those pixel value which is greater than the threshold value places to one. At the end of this process, each pixel values within the image are either zero or one, and the image has been modifying to binary form. After this conversion, the ridges in the fingerprint are highlighted with black color while valleys are highlighted with white color. Figure 3 shows the original grayscale image. Figure 4 shows the image after binarization. Binarization can be done in MATLAB using inbuilt function “im2bw”.

Fig. 3 Original Grayscale Image

2. Thresholding

The first technique considered focuses on finding the global threshold. The main black and white pixel values of each image are determined. The pixel range in between these pixel values is used to separate the black and white colors. Global binarization involves the formulation of a histogram consisting of the number of pixels versus the pixel value.

Fig. 4 Image after Binarization

3. Thinning

The aim of thinning is to reduce the fingerprint to lines one pixel wide. Thinning is a morphological operation performed on binary images. This is achieved by successive deletions of pixels from different sides of each image. (north, south, east, west) Each of the four sides is eroded away according to some set template. Eventually, the image being thinned will no longer possess any points which match the deletion templates. This remaining image will be the thinned representation of the original image. False minutiae which are included in false minutia structures like spikes, holes, bridges, ladder structures, and spurs are introduced to the fingerprint image after thinning the original image.

PERFORMANCE MEASURING METRICS

The accuracy of a fingerprint matching algorithm is calculated by:

FRR: It stands for false rejection rate. It can be defined as the ratio of the number of authentic images not considered qualified by the algorithm to the total number of authentic images. False rejection is also called “Type-I” error on most biometric systems. It happens when any system refuses to register employee’s own fingerprint as valid, failing to authorize that person.

FRR= (True claims rejected/Total true claims) ×100 %

FAR: It stands for false acceptance rate. It can be defined as the ratio of the number of impostor images considered as authentic by the algorithm to the total number of impostor images. False acceptance is also called “Type-II” error on most biometric systems. It happens when a system registers a punch made from a different employee, incorrectly identifying an unauthorized person.

FAR= (Imposter claim accepted/Total imposter claims) ×100 %

Failure to enroll (FTE): It is anticipated that nearly 4% of the population have indecipherable fingerprints. This consists of senior population, laborers who use their hands a lot and injured individuals. Due to the poor ridge structure present in such individuals, such users cannot be enrolled into the database and therefore cannot be subsequently authenticated. Such individuals are termed as ’goats’. A biometric system should have exception handling mechanism in place to deal with such scenarios.

CONCLUSION &FUTURE SCOPE

Fingerprint technology is the most extensively used form of biometric technology. Conventional knowledge-based password or personal Identification Number (PIN) and token based password, driver license, and ID card identifications are prone to fraud because PINs may be forgotten or guessed by others and the token may be lost or stolen. Therefore, biometric, which refers to identifying an individual based on the physiological or behavioral characteristics has been more reliable. Thinning is a morphological operation performed on binary images. This is achieved by successive deletions of pixels from different sides of each image. (North, south, east, west) Each of the four sides is eroded away according to some set template. Only thinking is not sufficient we have to first enhance the fingerprint image.

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