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A Study on Various Techniques for Fingerprint Recognition

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ABSTRACT

Various algorithms are used to operate a bio-metric system. It depends on techniques and procedures used in system implementation which ensure that how much the identification accuracy it can provide. The algorithms used in bio-metric systems should be well enough to recognize more and more bio-features of a person.
But, unfortunately, most of the bio-metric systems used have less efficiency in fingerprint matching due to lack of effective algorithm and techniques used. This has really become the complex issue of security that proper recognization of input details is not performed in security systems. The current article highlights the various techniques for fingerprint recognition.

1. Introduction

Templates are stored in the database of a bio-metric system. The problem in finger print matching can be the input of noisy or distorted bio-metric data. Due to some external factors, the outer layer of finger can be damaged causing some distorted data which is further matched with the stored templates and input data is not matched with the existing one due to damaged data.

In some cases, it is observed that improper alignment of the fingerprint image may lead to un-identification of finger prints matching as image enhancement and minutia matching & detection phase find it difficult to get the clear input data. As a result, the performance of the whole bio-metric system affects because image processing techniques tends to consume more time in the processing of improper alignment of the fingerprint image.

A fingerprint is the feature pattern of one finger (Figure 1). It is believed with strong evidences that each fingerprint is unique. Each person has his own fingerprints with the permanent uniqueness. So fingerprints have been used for identification and forensic investigation for a long time.

Figure 1 Fingerprint Image Acquired by an Optical Sensor

A fingerprint is composed of many ridges and furrows. These ridges and furrows present good similarities in each small local window, like parallelism and average width. However, shown by intensive research on fingerprint recognition, fingerprints are not distinguished by their ridges and furrows, but by Minutia, which are some abnormal points on the ridges (Figure 2).

Among the variety of minutia types, two are most significant and in heavy usage: one is called termination, which is the immediate end of a ridge; the other is called bifurcation, which is the point on the ridge from which two branches derive.

Fingerprint identification, known as dactyloscopy or hand print identification, is the process of comparing two instances of friction ridge skin impressions (see Minutia), from human fingers, the palm of the hand or even toes, to determine whether these impressions could have come from the same individual.

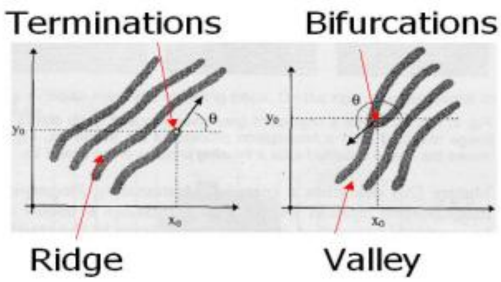

Figure 2: Minutia, Ridge, Valley, Termination and Bifurcation

The flexibility of friction ridge skin means that no two finger or palm prints are ever exactly alike in every detail; even two impressions recorded immediately after each other from the same hand. Fingerprint identification, also referred to as individualization, involves an expert, or an expert computer system operating under threshold scoring rules, determining whether two friction ridge impressions are likely to have originated from the same finger or palm.

2. Review of related Literature

Chunyu et al. (2014) deployed Gabor filter for the purpose of image enhancement. In this method, there is no need to decompose the image and for the purpose of image enhancement, refined Gabor filter is applied over the while image.

Elliott et al. (2014) proposed two approaches. In the first approach, the task of enhancing the fingerprint image was performed and in the second approach, the task of extracting minutia was done.

Girgisa et al. (2015) proposed bio-metric technique providing more accurate results as the sensors used in the system were so efficient that it was so easy to get the input data for further processing and results were obtained.

Loris et al. (2013) proposed a method for finger print image enhancement. This method was an integration of two methods i.e. Diffusion filter method and Gabor filter method. He further utilized two filters in this process and these two filters used were band-pass filter and low pass filter.

Nyongesa et al. (2012) proposed an algorithm for matching of finger prints and this algorithm is called edge detection algorithm. In this work, he used many edge operators which were further compared against their performance.

Robert et al. (2013) proposed an algorithm which proved to be quite effective in case of latent finger print image enhancement. Generally, the latent finger prints are not much clear and blur. This proposed algorithm helped a lot in recognizing these kinds of images.

Sambasiva et al. (2012) proposed a technique to extract better minutia from the blurred images so that more accurate results could be found. For this purpose, he performed the task of the filtration of low cost sensors.

Sawant et al. (2013) proposed a binarization technique so as to utilize the extracted edges. In this technique, the task of line following and thinning is performed repetitively until the clear input data is obtained to get accurate results.

Suen et al. (2012) proposed an image segmentation algorithm. He obtained the directions of ridge at each point of image by computing the orientation field.

Tang et al. (2013) proposed a decomposition method. Here, Gabor filter was applied to compute the orientation field from a group of images. This method is supposed to be more reliable than other methods of that generation.

Vijaya et al. (2012) used a neural network for the segmentation of finger print images. He used Fourier spectrum of fingerprint images for this purpose and it was observed that this method was quite effective in extracting the region of interest.

Wenjie et al. (2014) proposed an algorithm which was based on morphology and coherence. This algorithm was used in obtaining smooth regions. He further used this algorithm for the purpose of segmenting the fingerprint images.

Zhang et al. (2015) proposed architecture for the purpose of image thinning. The proposed hardware was based on pipeline architecture where the facility of selecting an optimal block size was also proposed.

3. Various techniques for fingerprint recognition

Following are the techniques for fingerprint recognition:

Minutia-based Technique:

Most of the finger-scan technologies are based on Minutia. Minutia-based techniques represent the fingerprint by its local features, like terminations and bifurcations. This approach has been intensively studied, also is the backbone of the current available fingerprint recognition products.

Ridge Feature Based Technique:

Feature extraction and template generation are based on a series of ridges as opposed to discrete points which forms the basis of Pattern based techniques. In case of very low quality fingerprint images, it may be difficult to extract the minutia points; hence the ridge feature based technique is preferred.

Correlation-based Technique:

Two fingerprint images are laid on top of each other and the correlation between corresponding pixels is compared for different alignments (various displacements and rotations). This technique has some disadvantages. Correlation-based techniques require the precise location of a registration point and are affected by non-linear distortion.

Image-based Technique:

Image based techniques tries to do matching based on the global features of a whole fingerprint image. It is an advanced and newly emerging method for fingerprint recognition. It is useful to solve some intractable problems of the first approach.

4. Fingerprint Image Pre-processing Stages

i) Binarization

The feature extraction algorithm in case of fingerprint's operates on binary images, thus there is a need to convert the gray scale image to a binary image. In which he black pixels represent ridges and the white pixels represent the valleys. Binarization is done to increase the contrast between the ridge and the valley and hence facilitates the extraction of minutia. The Gabor filter has a zero Direct Current (DC) component, which means the resulting filtered image has a mean pixel value of zero. Thus the global threshold for the binarization is zero; if the pixel value is greater than zero its set to one else it is set to zero. The result of binarization is an image which has only values of two pixels representing either a ridge or a valley.

The following figure 3 depicts the various fingerprint pre-processing stages:

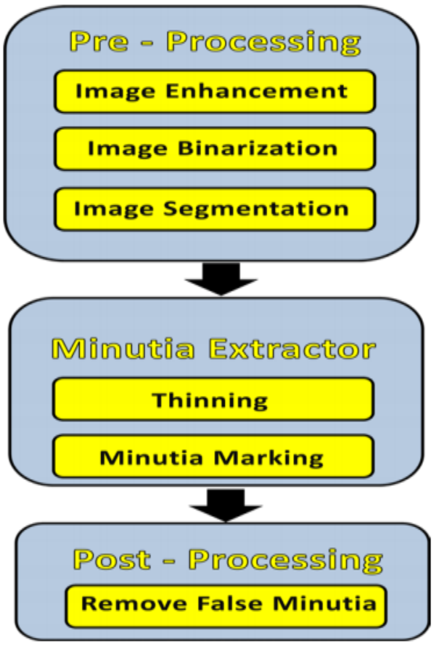

Figure 3: Fingerprint Pre-processing Stages

ii) 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 boundaries of the remaining effective area are sketched out since the minutia in the boundary region is confusing with those spurious minutia's that are generated when the ridges are out of the sensor.

iii) Thinning

The ROI bound binarized image needs to be thinned before the minutia can be extracted from the image. Thinning is a morphological operation that erodes the ridge pixels until they are one pixel wide. The thinning algorithm is one which follows infinite iterations till the ridge is one pixel wide. In each iteration, the neighbourhood of the pixel is considered and a set of pixel-deletion criteria are applied to obtain the skeleton of the image.

iv) Minutia Marking

After the fingerprint ridge thinning, marking minutia points is the next step to be followed. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending.

v) Fingerprint Image Post-processing

The minutia points obtained in the above step may contain many spurious minutia's. This may occur due to the presence of ridge breaks in the given figure itself, which could not be improved even after enhancement. This results in false minutia points which need to be removed. These unwanted minutia points are removed in the post-processing stage.

False minutia points will be obtained at the borders as the image ends abruptly. These are deleted using the segmented mask. As a first step, a segmented mask is created. This is created during segmentation carried out in the stage of pre-processing and contains ones in the blocks which have higher variance than the threshold and zeros for the blocks having lower variance. This segmented mask contains all ones in the regions where the image is located and all zeros at the other places. In this work, we didn't do any post processing to reduce spurious minutia. It counts spurious minutia's while estimating the false detection rate.

5. Conclusion

The analysis of fingerprints for matching purposes generally requires the comparison of several features of the print pattern. These include patterns, which are aggregate characteristics of ridges, and minutia points, which are unique features found within the patterns. Individuals generally have a mixture of pattern types on their fingertips, with some correlation between the left and right hands. While the loop pattern is the most common pattern, classification of individuals by assigning a pattern type to each of the ten fingers in an ordered fashion, serves as a first line of differentiation, however, no such classification is likely to be unique.

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