METHOD TO ENHANCE FEATURES OF BIOMETRICS SECURITY MANAGEMENT AND FINGERPRINT IDENTIFICATION USING LOW-QUALITY IMAGES

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Abstract- Fingerprint identification becomes the most well-known biometric system in nowadays. The system uses special fingerprint points called miniature which is unique for every person. Many systems have been used for various algorithms to do their identification process. Low-quality fingerprints are an unavoidable problem which occurs due to various reasons such as deformations of the skin and dryness. This research proposes a set of algorithms and provides a suitable solution for problems occurred by low-quality fingerprint images. Miniature marking use triplets, segmentation using morphological operations were used as the novel changes in this system. The novel triplet miniature method solved the alignment problem, which is a significant factor in extracting miniatures. The standard methods of Gabor filter was used for the image filtering. The proposed system, coded using MATLAB was successfully implemented and working same as other recognition systems.

Keywords- Fingerprint identification, Lowquality fingerprints, Miniature, Alignment, Gabor filter

I. INTRODUCTION

Recognition of people using biometrics is an emerging trend in the modern world. Biometrics gained a massive attraction in the industry due to the need for security for a broader range of applications. Among these, biometrics fingerprint became more popular because it is the most practical biometric and also secure and comfortable to collect.

Fingerprint structures are divided into three major classes or patterns, namely Arch, Loop, and whorl. These classes are further divided into five subclasses called Plain Arch, tented Arch, Left Loop, Right Loop, and Whorl. When we consider the three main classes following details can be found. [1]

Pre-processing, feature extraction, and post-processing are three main steps in a fingerprint system. Following figure 1.1 shows a general block diagram of a fingerprint identification system.

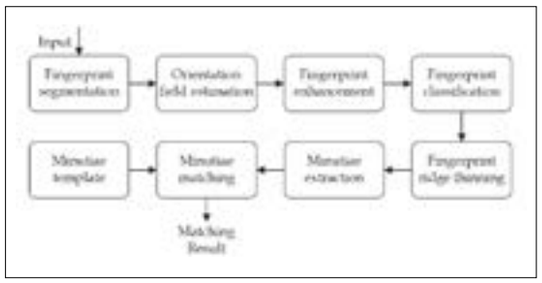

Figure 1.1 Block Diagram of a fingerprint machine Source : Ain Shams University, Egypt

The quality of the fingerprint images greatly affects the minutiae extraction process. To improve the performance of the system, many researchers put efforts into the image enhancement algorithms. Gabor filter and Fourier transformation are two of them. Gabor filter computes the response of eight oriented Gabor filters to determine whether a block belongs to the foreground or the background. Fourier Transform is a tool that decomposes the image into one and cosine components. It is a valuable image processing tool. When we input the image in the individual domain, the output will be in the frequency domain. Image compression, reconstruction, filtering & analysis are some applications using the Fourier transform.

The orientation field represents the orientation of the fingerprint. Estimate the orientation field the image was divided into 16*16 pixel blocks, and the gradient was calculated. From the gradient, information orientation angle is estimated. The orientation field is more important for latent fingerprints. Thinning process refers to the process of reducing the thickness of the lines as possible with minimum losses. This process is so important to identify the exact pattern of the fingerprint image.

One of the essential tasks considering an automatic fingerprint recognition system is the minutiae extraction from the captured image of the fingerprint. Due to imperfections of the acquired image, in some cases, certain minutiae can be missed by the extraction algorithm, and in other cases, spurious minutiae can be inserted. Therefore, it is important to choose an algorithm that solves all these questions.

A. Image matching techniques for low-quality images.

Matching fingerprints from a high-quality image is not a problem, but when it comes to low-quality images, it becomes harder. In the real world, not every fingerprint is clear. Therefore, it is important to consider how to deal with low-quality ones.

Cross-correlation is an efficient method for recognizing low-quality fingerprints. Correlation-based helps to work with images that are in low quality, damaged, incomplete or have shaped distortions. [31]

Phase -based image matching is another method for matching low-quality fingerprints. The use of phase components in 2D (two-dimensional) discrete Fourier transforms of fingerprint images makes possible to achieve highly robust fingerprint recognition for low-quality fingerprints. [26]

Phase only correlation can also be used for matching low quality fingerprints. This method makes possible estimate image displacement with 1/100 –pixel accuracy. [30]

There are many methods proposed for the extracting features from low-quality images that do not provide a perfect answer to the problem. The main aim of this research is to build a method that enhances extracting features from low-quality images.

II. METHODOLOGY

A. Fingerprint pre-processing

Fingerprint pre-processing contains four stages

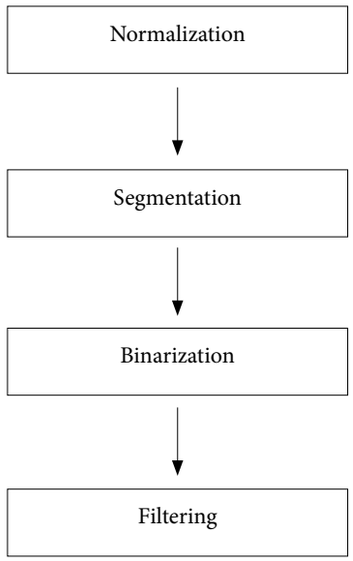

Figure 2. Pre - processing steps

1) Normalization: Normalization is done to identify the ridges and valleys easily. To do normalization. range between the ridges and valleys must be decreased. In the system, simple histogram equalization is done, which enhances the contrast of the image by transforming the values in the fingerprint image.
2) Segmentation: Orientation field represents the local orientation of the ridges contained in the fingerprint. From the normalized image orientation of the ridges are calculated in each block of the desired size. Three step approach fulfils the task.

i. Block direction estimation

ii. Segmentation by direction intensity

iii. Region of interest extraction.

Also, using morphological operations like erosion for extraction of ROI is introduced in this system.

3) Image binarization: Image binarization is a process which transforms the 8-bit grey image to a 1-bit image with 0 value for ridges and 1 value for furrows. To binarization, the image of a locally adaptive binarization method is performed. The image was divided into 16* 16-pixel blocks. Binarization of the image is done by an im2bw function within an inbuilt Matlab function.

4) Filtering: Gabor filters are used mainly in feature extraction, stereo disparity information and texture analysis in image processing and computer vision areas. Gabor filter is a special kind of bandpass filters. Bandpass filters are filters that allow necessary frequency bands and reject others. The sinusoidal-shaped waves of ridges and valleys very slowly in a constant local orientation. A bandpass filter, when tuned on a necessary frequency band, can remove unnecessary noise from the image. Therefore, it is better to use Gabor filters to filter these noises. Gabor filter is applied to an image if mainly concentrates on the edges and changes in the texture.[15]

Structure of the Gabor filter,

$$G(x,y,\theta,f) = \exp\left\{-\frac{1}{2}\left[\frac{x_\theta^2}{\sigma_x^2}+\frac{y_\theta^2}{\sigma_y^2}\right]\right\}\cos\left(2\pi f x_\theta\right),$$

$$x_\theta = x\cos\theta + y\sin\theta$$

$$y_\theta = -x\sin\theta + y\cos\theta$$

An im2bw function inbuilt Matlab function did binarization of the image. For the image preprocessing stage Histogram equalization and Fourier transform are used.

B. Miniature extraction

Miniature extraction contains following steps,

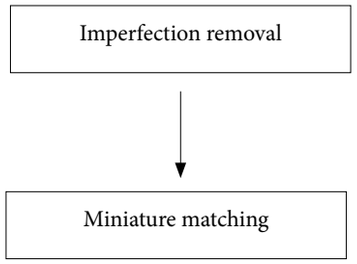

Figure 3. Post processing stages

1) Thinning: The second class of thinning algorithm is parallel. In parallel thinning algorithm results of the previous iteration is used for the decision for individual pixel deletion. This considers 3*3 neighbourhood around the chosen pixel. Rules of deletion applied according to the neighboring pixels. Entirely parallel algorithms have problems incorrectness. Therefore, they are broken into sub-iterations. In the method used midpoints of the black spaces are found and then joined to form a skeleton. This is fast but sometimes tends to produce noisy skeletons. After testing few thinning algorithms, the morphological thinning operation used because of high efficiency and good thinning quality.

2) Feature extraction: The system is based on matching miniature points, and it only considers ridges and bifurcations as a miniature. Extracting miniature is the most important part of the system. Due to various reasons, there will be false miniature. Various methods are introduced to remove or reduce false miniature.

After preprocessing the image extracting miniature, the image produces a large number of spurious miniatures. To remove those following heuristics like when there is a cluster of miniature in the same area are all removed. Accept the one in the centre and also if two miniatures are facing each other and there are no ridges between them both miniatures are removed from the set are used.

C. Post-processing stage

1) Imperfection removal: After thinning imperfections of the original image may remain to a certain extent depending on the image quality. This is spurious cause miniature. Therefore an algorithm must be made to remove lines not corresponding to ridges and connect broken ridges.

2) Miniature matching: Miniature matching is the most crucial step in the system. Here we match the miniature obtained from two sample fingerprints to check whether they are from the same person or not. Before doing the matching, we must consider the alignment of the image. Alignment of the image is important to match the fingerprint correctly because there can be plastic deformations in the finger. For this many systems use details of ridges or the Hough transform which are complicated to implement. There are three steps in the miniature matching stage,

i. Ridge correlation to specify reference miniature pair

ii. Align two fingerprint image

iii. Miniature match

In the system triplets of the miniature are formed, and distance from the other two miniatures and the angle between them are stored in a table. Then these tables are brute forced to do the matching. If we have n miniature n (n-1) (n-1) /6 triplets are formed for the fingerprint.

By this way, there is no need to rotate the image and do the matching. However, the problem is it takes time to do the matching. The system uses details from bifurcations because the probability of getting spurious details by the dry or low-quality image is a higher range. However, by using the good matching algorithm use ridge ending details also.

III. RESULTS

Statistical results were calculated with by matching images in the database. Genuine and imposter results show the scores obtained when we match fingerprints of the same person and when we match with the fingerprint of a different person. Imposter scores spread below 30%, while genuine score lies or spreads above that.

False Acceptance Rate (FAR) is the likelihood of the system to match or accept imposter fingerprints. In other words, FAR is the number of imposter scores that lies or spreads above the threshold value.

False Recognition Rate (FRR) is the likelihood of the system to reject genuine fingerprints. In other words, FRR is the number of genuine scores that lie below the threshold. 0.0329 equal error rate was found when the value of the threshold is 0.2623. Here, when the FAR and FRR is equal they are called Equal Error Rate. Accuracy of the system depends on EER. When EER is low, Accuracy of the system is high.

Following are some image results from the system,

Figure 4. Enhanced image

Figure 5. Binarization

Figure 6. Thinned

Figure 7. Feature extraction

The system successfully identifies whether two fingerprints belong to the same person or not. However, sometimes system produces erroneous results. Also, the computational time of the algorithm is high for a real-time application.

To make this method more efficient some places show scope for improvement. Image enhancement and miniature matching algorithm are some areas that need to be improved. The system produces perfect results when the image quality is high. But it's the real world, it may real differently because the fingerprint may be too wet or too dry. Also, deformations in the skin may occur in the real world.

IV. CONCLUSION

The main objective of this research was to build a security system that answers the low quality image problem. After a broad investigation, this system was build combining the best methods in the current world. This system also provides a solution for alignment of the image. The system follows all the necessary steps in an average identification system.

The existing system was upgraded using a new segmentation method, Gabor filter and also a new type of miniature and also with a database. These methods were used to increase the efficiency of the system for low-quality images. Also, some novel changes like using triplets of miniature to do the matching, segmentation using morphological operations are found in the system which was not reported in the literature referred.

Coding the system with MATLAB and going through all the stages of the fingerprint was helpful to understand key issues of fingerprint recognition. The algorithm used is not very robust and also vulnerable to plastic deformations and scaling. Various new algorithms have been found that gives better results.

The major challenge in the fingerprint recognition lies in the pre-processing of low-quality images. Still, a perfect answer for this has been not found.

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