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FINGERPRINT IMAGE ENHANCEMENT AND MINUTIA MATCHING

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ABSTRACT

Biometric recognition is known as the use of distinctive physiological and behavioural characteristics like fingerprint, palm print, iris, face gait, signature etc. For recognizing individuals, Fingerprint recognition is one of the oldest and most reliable biometric features used for personal identification. Generally fingerprint images are of low quality to extract features. Main aim of this paper is to overcome this problem. We are using CLAHE (contrast limited adaptive histogram equalization) is applied to enhance the contrast of small tiles and to combine the neighbouring tiles in an image by using bilinear interpolation, which eliminates the artificially induced boundaries so that we can easily extract features from fingerprint image[2]. In this paper we are using minutia point extraction and matching technique for identifying individual fingerprint.

KEYWORDS: *Biometrics, CLAHE, Image Enhancement, Fingerprint, Minutiae.*

I. INTRODUCTION

Old technique like password based and token based for authentication become obsolete due to password hacker and replaced by strong identity authentication which is based on biometric feature such as face, iris, voice, hand geometry, handwriting, retina, and fingerprints. Fingerprint identification is the well known and publicized biometrics technique[7]. Because of their uniqueness and consistency over time they provide High security authentication system for safe access. Fingerprint identification is popular due to ease acquisition, availability and user friendly, and there established use and collections by law enforcement features.

1.1 Fingerprints

A fingerprint is comprised of ridges and valleys. The ridges are the dark area of the fingerprint and the valleys are the white area that exists between the ridges. Figure 1.1 shows afingerprint image. in case of a fingerprint identification system, we would need to match the incoming fingerprint with stored templates of every other user in the database[8]. In order to reduce this computation and search overhead, it is essential to have some kind of fingerprint classification system which will help us to severely restrict the size of the database for which we need to extract minutiae features and match against the incoming fingerprint sample.

Figure 1.1: Fingerprint image

Hence, fingerprints can be classified into one of six categories based on their geometric structure as shown in figure 1.2.

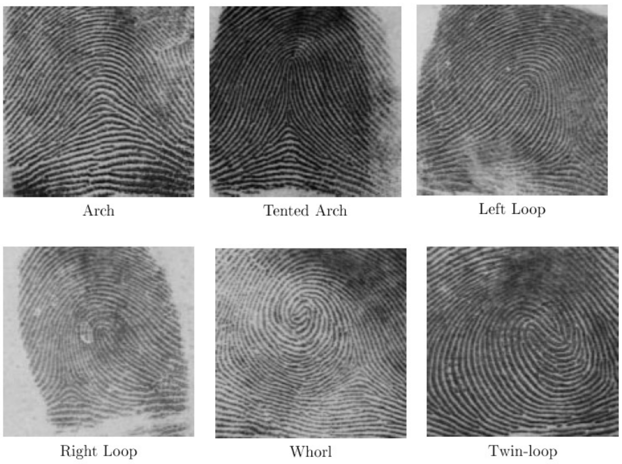

Figure 1.2 classification fingerprint image

By classifying fingerprints on the above basis we can make the database to be searched much smaller[6]. Also, if images from multiple fingers are used, we will have many more categories and the size of the database to be searched will decrease further.

1.2 *Minutiae Points*

Minutiae are major features of a fingerprint, using which comparisons of one print with another can be made. Minutiae include the following: Ridge ending, Ridge bifurcation, Short ridge, or independent ridge, Island, Ridge enclosure, Spur, Crossover or bridge and Delta[1]&[6]. There are two main types, known as ridge endings and bifurcations. Sometimes, other details, such as the points at which scars begin or terminate, are considered minutiae. A ridge ending is defined as the point where the ridge ends abruptly and the ridge bifurcation is the point where the ridge splits into two or more branches. Figure 1.2 shows Different minutiae feature.

Figure 1.3 different minutia feathers in fingerprint

II. IMAGE ENHANCEMENT

For minutiae extraction we need good quality image however obtaining a good quality fingerprint image is not always easy in most of cases they may be corrupted and degraded due to variation in skin and effective condition. So the fingerprint image must be enhancing before matching. Generally Following four operation are performed in image enhancement process.

2.1 Normalization

As a first step of the fingerprint image enhancement process, histogram equalization is applied to enhance the image's contrast by transforming the intensity values of the image (the values in the colour map of an indexed image), which are given by the following equation:

$$s_k = T(r_k) = \sum_{j=1}^{k} p_r(r_j) = \sum_{j=1}^{k} \frac{n_j}{n} \qquad (1)$$

Where sk is the intensity value in the processed image corresponding to rk in the input image, and pr (rj) =1, 2, 3... L is the input fingerprint image intensity level. However, by enhancing the contrast of an image through a transformation of its intensity values, the histogram equalization can amplify the noise and produce worse results than the original image for some fingerprints, due to many pixels falling inside the same gray level range. Therefore, instead of applying the histogram equalization, which works on the whole image, CLAHE (contrast limited adaptive histogram equalization)[2] is applied to enhance the contrast of small tiles and to combine the neighbouring tiles in an image by using bilinear interpolation, which eliminates the artificially induced boundaries.

Original fingerprint After CLAHE

Figure 2.1 Normalization operation

In addition, the 'Clip Limit' factor is applied to avoid over saturation of the image specifically in homogeneous areas that present high peaks in the histogram of certain image tiles due to many pixels falling inside the same gray level range [2]. Additionally, a combination of filters in both domains, spatial and Fourier is used to obtain a proper enhanced image.

2.2 Binarization:

The fingerprint binarization is an algorithm producing a 1-bit type image, with 0 as ridges which are tinted with black and 1 as valleys which are tinted with white [8]. However, the adaptive binarization method is based on a threshold t, with gray-level pixels lower than t assigned to 0 and the others to 1. It is known that dissimilar fingerprint images have special contrast and intensity, and therefore, a unique threshold t is not proper for a general fingerprint image analysis [1]. The local threshold technique changes t locally, by adapting its value to the average local intensity. In this paper this method is applied based on determining the mean value of each 32-by-32 input matrix and transferring the pixel value to 1 if it is larger than mean and to 0 if it is smaller. However, in very poor quality fingerprint images, the local threshold method cannot guarantee acceptable results and a special threshold, which has sufficient effect, is required [9]. This threshold having sufficient affection was determined on the tested.

Figure2.2: After Binarization

2.3 Thinning:

Thinning is the last step of the fingerprint image enhancement before feature extraction, and it is used in order to clarify the endpoints and the bifurcations in each specific pixel, subject to the numbers of pixels belonging to these features in the original fingerprints [7]. Different thinning algorithms and techniques have been developed but they are based on thinning the neighbourhood of the pixels that have maximum values in a sequential process obtaining a characteristic pixel value for each feature at each step[3] &[4]. In addition, because of false breaks and lonely points which could appear when using such algorithms, the fingerprint images have to be filtered in order to remove them. In this paper an algorithms has been developed, which eliminates the development of such false information in a fingerprint image by using initially a slide neighbourhood processing and then thinning the result in only one step without any intermediate filtering and with a substantial reduction of the computational complexity [5].

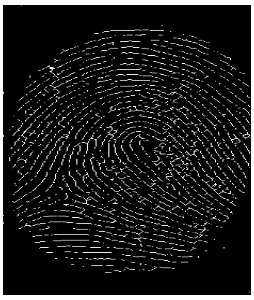

Figure2.3: After Thinning

Minutiae-based Methods

Minutiae matching are certainly the most authentic and widely used method for fingerprint matching. Let **T** and **I** be the representation of the template and input fingerprint, respectively. Most common minutiae matching algorithms consider each minutia as a triplet **m = {x, y, Θ}** that indicates the x, y minutia location coordinates and the minutia angle Θ:

$$\mathbf{T}=\{\mathbf{m}_1,\mathbf{m}_2,...,\mathbf{m}_m\},\quad \mathbf{m}_i=\{x_i,y_i,\theta_i\},\quad i=1..m$$
$$\mathbf{I}=\{\mathbf{m}'_1,\mathbf{m}'_2,...,\mathbf{m}'_n\},\quad \mathbf{m}'_j=\{x'_j,y'_j,\theta'_j\},\quad j=1..n,$$

where m and n denote the number of minutiae in T and I, respectively[6]. A minutia m'j in I and a minutia mi in T are considered "matching," if the spatial distance (sd) between them is smaller than a given tolerance r_0 and the direction difference (dd) between them is smaller than an angular tolerance Θ_0.

$$sd(\mathbf{m}'_j,\mathbf{m}_i)=\sqrt{(x'_j-x_i)^2+(y'_j-y_i)^2}\le r_0,\quad \text{and} \qquad (5)$$
$$dd(\mathbf{m}'_j,\mathbf{m}_i)=\min\left(|\theta'_j-\theta_i|,360^\circ-|\theta'_j-\theta_i|\right)\le\theta_0. \qquad (6)$$

R_0 and Θ_0 are necessary to compensate for errors in feature extraction process and to account for small plastic deformations. Aligning the two fingerprints is a mandatory step in order to maximize the number of matching minutiae. Correctly aligning two fingerprints certainly requires displacement (in x and y) and rotation (Θ) to be recovered and likely involves other geometrical transformations like scale resolution and other kinds of distortion. Let map(.) be the function that maps a minutia m'j (from I) into m"j according to a given geometrical transformation; for example, by considering a displacement of [Δx, Δy] and a

Counter clockwise rotation Θ around the origin.

$$map_{\Delta x,\Delta y,\theta}\left(\mathbf{m}'_j=\{x'_j,y'_j,\theta'_j\}\right)=\mathbf{m}''_j=\{x''_j,y''_j,\theta'_j+\theta\},\quad \text{where}$$
$$\begin{bmatrix}x''_j\\ y''_j\end{bmatrix}=\begin{bmatrix}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{bmatrix}\begin{bmatrix}x'_j\\ y'_j\end{bmatrix}+\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix}.$$

Let mm(.) be an indicator function that returns 1 in the case where the minutiae m"j and mi , match according to Equations 5 and 6.

$$mm\left(\mathbf{m}''_j, \mathbf{m}_i\right) = \begin{cases} 1 & sd\left(\mathbf{m}''_j, \mathbf{m}_i\right) \le r_0 \quad \text{and} \quad dd\left(\mathbf{m}''_j, \mathbf{m}_i\right) \le \theta_0 \\ 0 & \text{otherwise.} \end{cases}$$

Then, the matching problem can be formulated as where P(i) is an unknown function that determines the pairing between I and T minutiae; in particular, each minutia has either exactly one mate in the other fingerprint or has no mate at all:

1) P(i) = j indicates that the mate of the mi in T is the minutia m'j in I;
2) P(i) = null indicates that minutia mi in T has no mate in I;
3) A minutia m'j in I, such that for all i = 1..m, P(i) ≠ j has no mate in T;
4) For all i = 1. m, k = l..m, i ≠ k => P(i) ≠ P(k) or P(i) = P(k) = null (this requires that each minutia in I is associated with a maximum of one minutia in T).

Minutia Match:

Given two set of minutia of two fingerprint images, the minutia match algorithm determines whether the two minutia sets are from the same finger or not. An alignment-based match algorithm partially derived from the [6] is used in this work. It includes two consecutive stages: one is alignment stage and the second is match stage.

1) **Alignment stage:** Given two fingerprint images to be matched, choose any one minutia from each image; calculate the similarity of the two ridges associated with the two referenced minutia points. If the similarity is larger than a threshold, transform each set of minutia to a new coordination system whose origin is at the referenced point and whose x-axis is coincident with the direction of the referenced point.
2) **Match stage:** After the set of transformed minutia points is derived, the elastic match algorithm is used to count the matched minutia pairs by assuming two minutia having nearly the same position and direction are identical.

III. RESULT

If we use CLAHE with clip limit technique for image enhancement and minutia feature extracting technique for fingerprint image feature extraction and matching we see that they produce better result in comparison some other technique. Two indexes are well accepted to determine the performance of a fingerprint recognition system:

1) **False Rejection Rate (FRR):** For an image database, each sample is matched against the remaining samples of the same finger to compute the False Rejection Rate
2) **False Acceptance Rate (FAR):** Also the first sample of each finger in the database is matched against the first sample of the remaining fingers to compute the False Acceptance Rate[1].

In our experiments FAR and FRR values were 25-30% approximately. Thus at a threshold match score of about 28 the verification rate of the algorithm is about 70-75%. The relatively low percentage of verification rate is due to poor quality of images in the database and the inefficient matching algorithm which lead to incorrect matches.

IV. CONCLUSIONS

Different methods in the public domain for fingerprint image enhancement have been reviewed, and a new methodology allowing superior performances is proposed[1]. In order to avoid specific shortfalls of this process, the procedure follows first the application of CLAHE with Clip Limit in order to enhance the contrast of small tiles, to eliminate the artificially a program coding with MATLAB going through all the stages of the fingerprint recognition is built. It is helpful to understand the procedures of fingerprint recognition. And demonstrate the key issues of fingerprint reorganization[2].

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