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Algorithm for Fingerprint Verification System

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Abstract

Extraction of minutiae based features from good quality fingerprint images is more effective for fingerprint recognition in comparison with features from low quality fingerprint. In this paper, a new technique for fingerprint feature extraction based on ridge pattern is proposed. Robust features are extracted from fingerprint image notwithstanding the quality of the image. The variation within different person fingerprint is established using centre of gravity of the fingerprint image as the reference point for effective classification. Similarity measure in term of Euclidean distance is compute for test fingerprint images

Keywords: fingerprint, orientation features, centre of gravity, ridge pattern and euclidean distance

INTRODUCTION

Fingerprint recognition is one of the oldest and most important research areas in the field of pattern recognition. Among biometric trait, fingerprint is widely accepted for person identification because of its uniqueness and immutability. It is used widely in access control for commercial and residential application, also used for time and attendance system. Fingerprint image can be produced either by offline or online, in the offline method; fingerprint image is obtained by impressed inked fingertip on a paper, which is then scanned to the computer while in online technique, fingerprint image is produced when a finger is impressed against a biometric sensor that is connected to a computer. Generally fingerprint can be classified into three classes namely: rolled/full, plain/flat and latent. Rolled fingerprint images are obtained by rolling fingertip pattern on capturing material from one side to other side. Plain or flat fingerprint images are obtained by pressed down fingertip pattern on flat surface of capturing material while latent fingerprint image are obtained from object touched by fingerprint (Kumar, 2009; Nawaz, 2009).

Fingerprint is captured as pattern of interleaved ridges and valleys image. The ridges are black lines and the valleys are the white line, they form various types of ridges patterns classified as left loop, right loop, arch, whorl and tented arch. The ridges are characterized by distinctive feature known as minutia. Minutiae points occur as ridge ending or bifurcation. Bifurcations are points at which a ridges splits into two ridges. The accuracy of fingerprint recognition system mainly depend s on effectiveness of the extracted features. The accuracy of the system is determined by compute the False Acceptance Rate (FAR) and False Rejection Rate (FRR) of the system. If a registered user of a system is wrongly recognized

as an imposter the corresponding error rate is called the False Rejection Rate (FRR); an imposter could be also mistakenly recognized as genuine person the corresponding error rate is called the False Acceptance Rate (FAR).

Different methods have been used for extraction of feature from fingerprint image, this includes minutiae based features extraction and ridges pattern based feature extraction. Minutiae based features extraction involves extraction of ridges ending and ridge bifurcation from gray-scale or thinned binary fingerprint images (Malathi, 2010; Ravi, 2009; Jaam, 2006; Afsar, 2004; Seshadri, 2010). The minutiae-based system perform well with high quality fingerprint image but it's perform degrade with low quality of fingerprint images. The quality of fingerprint is usually affected by the condition of the skin and sensor noise. False minutiae are produced as small breaks in the curves on fingerprint image due to uneven surface pressure and deteriorate finger skin therefore cause false feature representation. Also feature extractions based on other techniques have been proposed. Image-based fingerprint identification method is proposed by (Kekre, 2010). Feature vectors of a fingerprint are extracted after sectorization of the cepstrum of a fingerprint and matching is done using Euclidean distance as similarity measure. Fingerprint recognition technique based on embedded Hidden Markov Model is proposed by (Singh, 2010). Fingerprint orientation is used for modeling and classification. The orientation fields are obtained from block of Fingerprint image, The image is scanned with sampling window left to right and top to bottom forming a image blocks matrix as feature representation. Also fingerprint recognition method using Zernike moments is presented by (Quader, 2007). The approach is based

on localizing the matching regions in fingerprint using only the information related to the core points. Zernike Moment is used as feature extractor on the region of interest while Euclidean distance is used to compute distance between feature vectors. An efficient ANN based approach for latent fingerprint matching was proposed by (Gupta and Kumar, 2010). The algorithm made use of region and line structures that exist between minutiae pairs. The feature extraction methods mentioned above are not satisfying because the effective of these methods depend on quality of input fingerprint image. In many cases vital information needed to generate robust feature is lost using the above methods. A robust feature is required for higher accuracy method notwithstanding the quality of the fingerprint image. In this paper, an effective feature extraction method based on centre of gravity as the reference point is presented. Robust fused size-orientation feature are generated from image cells, which function as input to Euclidean distance classifier. The rest of the paper is organized as follows section 2 provides the description of the proposed algorithm; these include fingerprint image preprocessing, feature extraction and fusion method while section 3 presents training and classification algorithm. Section 4 discusses the analysis of verification result and finally, conclusion is presented in section 5.

PROPOSED FINGERPRINT VERIFICATION ALGORITHM

The proposed fingerprint verification algorithm flows is shown in Fig.1. The data acquisition component is the first phase. The second phase comprise of the preprocessing steps.

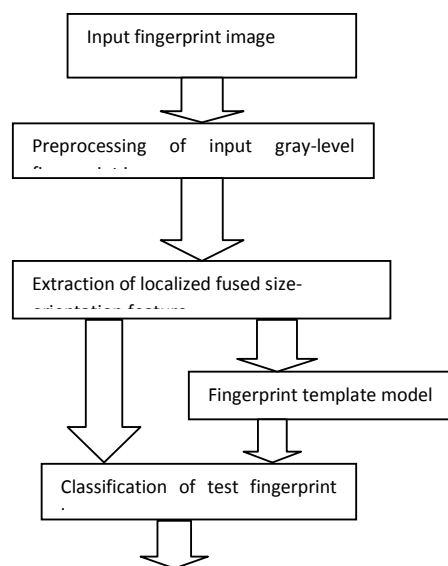


Fig.1: Algorithm flow of the proposed fingerprint verification method

The third component employs a feature extraction algorithm to produce a feature vector whose best describe the characteristic of the fingerprint image notwithstanding the quality of the input image. The fourth component of the system generates the subject fingerprint image model. The last component compares feature vectors to produce a score which indicates the degree of similarity between the test fingerprint and subject fingerprint models.

Input Fingerprint image

The input fingerprint images are obtained from FVC2004-DB1. The database contains 100 fingers and 8 impressions per finger. The size of each image is 640x480 pixels and its resolution is 500dpi (Maio, 2004). Sample of fingerprint images from the database is as shown in fig 2



Fig.2: Fingerprint image samples

Preprocessing of Fingerprint Image

The example of input gray-level fingerprint image to the proposed fingerprint verification algorithm is shown in fig3. Noise reduction and image enhancement are done and it is converted to binary image. Morphological operation is carried out on the binary image in order to thin the foreground pixels until they are one pixel wide. The output fingerprint image from the preprocessing algorithm is as shown in fig 4.



Fig 3. Input gray-level fingerprint image



Fig.4. Preprocessed fingerprint image

Feature Extraction Algorithm

In this paper, a new feature extraction technique based on fingerprint image blocks is presented. The centre of gravity of the fingerprint image is used as the reference point for image partition into smaller image blocks. The whole image pattern is partitioned into rectangular cells at moderate resolution in such way that all orientation information of the ridges directions is acquired. Two robust invariant features are extracted from the fingerprint image. The extracted features are able to capture foreground pixel position and orientation characteristic at local level. The features are image cell size (S) and image cell orientation (Θ). The feature extraction algorithm is stated as follows:

- (1) Locate fingerprint image bounding box.
 - (i) Scan the thinned image from top to bottom to obtain the image height.
 - (ii) Scan the thinned image from left to right to obtain the image width.
- (2) Centralization of the fingerprint image.
 - (i) Calculate centre of gravity of the fingerprint image using Eq. (1).

$$\bar{x} = \frac{1}{A} \sum_{i=1}^n \sum_{j=1}^m jI(i, j)$$

$$\bar{y} = \frac{1}{A} \sum_{i=1}^n \sum_{j=1}^m iI(i, j) \tag{1}$$

Where I is n x m matrix representing the region of interest and A is the size of the region.

- (ii) Then move the image centre (reference point) to coincide with centre of the predefined image space.
- (3) The image is partitioned into four sub-image parts shown in fig5.

- (i) Through point \bar{x} make a horizontal splitting across the image.
 - (ii) Through point \bar{y} make a vertical splitting across the image.
- (4) Partition each sub-image part into four rectangular image blocks.
 - (i) Locate the centre of each sub-image part using (1).
 - (ii) Repeat step 3 (i) and 3(ii) for each sub-image part, to obtain a set of 16 image blocks.
- (5) Partition each of the image block parts into four smaller image blocks
 - (i) Locate the centre of each of the image blocks using (1).
 - (ii) Repeat steps 3 (i) and 3 (ii) for each image blocks, to obtain a set of 64 smaller image cells.
- (6) Find the size of each of the 64 smaller image cells.
 - (i) Calculate the height and width of each image cells.

The feature extracted at stage 6; constitutes the set of the first feature (S).
- (7) Calculate orientation of the region of the image cell.
 - (i) Calculate the angle at which the sum of squared distance between region points and moment of the inertia will be minimum using (2).

The feature extracted at stage 7 constitutes the set of the second feature (Θ).

$$\theta = \frac{1}{2} \tan^{-1} \frac{b}{a - c} \tag{2}$$

The value of a, b and c are given by (3), (4) and (5) respectively.

$$a = \sum_{i=1}^n \sum_{j=1}^m (x - \bar{x})^2 I[i, j] \tag{3}$$

$$b = 2 \sum_{i=1}^n \sum_{j=1}^m (x - \bar{x})(y - \bar{y}) I(i, j) \tag{4}$$

$$c = \sum_{i=1}^n \sum_{j=1}^m (y - \bar{y})^2 I(i, j) \tag{5}$$

Fusion of Cell size and Cell Orientation Features

This technique is design to effectively compute fused feature vector containing information from both the cell size and cell orientation features and used this vector for subsequent stages. Information from two feature value can be combined at feature extraction stage or at decision level stage. The accuracy of the system also depends on the level of fusion and the discriminative ability of fused data. In this work, cell size feature is combined with orientation feature at feature level. The steps involve are stated as follows: Given that extracted cell size feature is $S = s_1, s_2, s_3, \dots, s_{64}$

- (1) Calculate the mean feature vector of cell size feature (S) using (6).

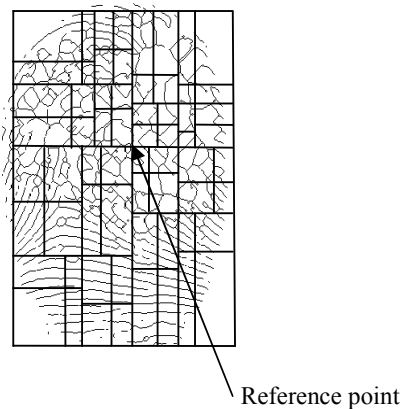
$$\bar{\mu}_s = \frac{1}{N} \sum_{i=1}^N s_i \quad (6)$$

- (2) Calculate the variance of cell size (S) using (7).

$$\sigma_s^2 = \frac{1}{N} \sum_{i=1}^N (s_i - \bar{\mu}_s)^2 \quad (7)$$

- (3) Normalize cell orientation features vector (Θ) using variance (σ_s^2). The fused feature ($F_{s\theta}$) becomes:

$$F_{s\theta} = \left[\frac{\theta_1}{\sigma_s^2}, \frac{\theta_2}{\sigma_s^2}, \frac{\theta_3}{\sigma_s^2}, \dots, \frac{\theta_{24}}{\sigma_s^2} \right] \quad (8)$$



TRAINING AND CLASSIFICATION

In the training stage, threshold value for each subject is calculated independently based on fused feature. Six out of the eight fingerprint image are used to determine this threshold value. Given that six training fingerprint samples are represented as $T_1, T_2, T_3, T_4, T_5,$ and T_6 the corresponding feature vector components of each fingerprint is represented as $t_1, t_2, t_3, \dots, t_{64}$. That is:

$$T_1 = [t_{1,1}, t_{1,2}, t_{1,3}, \dots, t_{1,64}]$$

$$T_2 = [t_{2,1}, t_{2,2}, t_{2,3}, \dots, t_{2,64}]$$

$$T_3 = [t_{3,1}, t_{3,2}, t_{3,3}, \dots, t_{3,64}]$$

$$T_4 = [t_{4,1}, t_{4,2}, t_{4,3}, \dots, t_{4,64}]$$

$$T_5 = [t_{5,1}, t_{5,2}, t_{5,3}, \dots, t_{5,64}]$$

$$T_6 = [t_{6,1}, t_{6,2}, t_{6,3}, \dots, t_{6,64}]$$

The fingerprint template feature vector of each of the subject is obtained by finding the mean values (t_{mean}) of each corresponding feature vector components. Therefore the fingerprint model for each of the subject is represented by (9).

$$T_f = [t_{mean,1}, t_{mean,2}, \dots, t_{mean,64}] \quad (9)$$

The threshold for each of the subjects is obtained using (10) given that (σ_f) is the standard deviations of the training feature vector components.

$$Threshold(th) = \sqrt{\sum_{f=1}^{64} \sigma_f^2} \quad (10)$$

ANALYSIS OF VERIFICATION RESULT

The Euclidean distance measure is one of the most suitable classifier used to obtain distance measurement between two vectors of equal size on a two dimensional plane (Daramola, 2008). In this work, given that T_f is the template feature vector of size $f = 64$ of the each of the subject. And I_f the incoming feature vector of size $f = 64$. Euclidean distance (d) between the query fingerprint feature vector and each of the template feature vector of the subjects in the database is calculated by using (11).

$$(d) = \sqrt{\sum_{f=1}^{64} (T_f - I_f)^2} \quad (11)$$

The Euclidean distance (d) of equation (11) and threshold (t) of equation (10) is compared for each user. If (d) is less than or equal to (th) for any of the users, then the incoming query fingerprint is recognized by the system otherwise rejected.

CONCLUSION

Fused feature vector is extracted from the preprocessed low quality fingerprint image taking into consideration the position and orientation of pixels using image centre of gravity as the reference point. The performance of the proposed automatic fingerprint verification algorithm depends on the discriminative ability of the fused feature vector used to represent the image. This algorithm will achieve better result in comparison with previous single feature based methods.

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