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SVM-BDT Based Intelligent Fingerprint Authentication System using Geometry Approach

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Abstract

Fingerprint recognition is a method of biometric authentication that uses pattern recognition techniques based on high-resolution fingerprints images of the individual. . The steps for Fingerprint recognition include image acquisition, preprocessing, feature extraction and matching. In the present work, a new fingerprint feature detection algorithm has been proposed. It has been found that presence of noise in fingerprint images leads to spurious minutiae. To overcome this problem, feature extraction has been done which efficiently determine the minutiae points in fingerprint.The proposed method can be used in matching the template for finding bifurcation and termination. The feature of the fingerprint is extracted by statistical and geometry approach. Fingerprint minutiae are compared on their positions relative to the reference points, using a set of thresholds for the various matching features. In this paper, Support Vector Machine classifier utilizing binary decision tree (SVM-BDT) for solving multiclass problems is implemented. During recognition phase, due to its logarithmic complexity, SVM-BDT is much faster than the widely used multi-class SVM methods. For a test pair of fingerprints, a similar set of minutiae correspondences is extracted and given to the recognizer, using only those classified as genuine matches to calculate the similarity score, and thus, the matching result yields higher Genuine Acceptance Rate(GAR) and reduced False Acceptance Rate(FAR). Key words: Feature extraction, Support Vector Machine classifier utilizing Binary Decision Tree (SVM-BDT), Hyper plane, Geometry approach, Intelligent Fingerprint Recognition System(IFR), Genuine Acceptance Rate(GAR) ,False Acceptance Rate(FAR), crossing number (CN),Trained Database.

1 INTRODUCTION

The biometrics is the automatic person identification claimed identity verification of an individual by using certain physiological or behavioral features associated with a given person. In physiological characteristic, fingerprint recognition is a computer system to obtain the personal identifiably possible because two persons should not have the same fingerprint characteristic. In addition, these characteristics cannot be altered. The primary purpose of fingerprint identification is for crime prevention. Fingerprint recognition system has been successful for many application areas such as computer login, bank account recovery, and cheque processing. But the fingerprint recognition system still faces with defect in accuracy rate. The primary objectives of the proposed system will perform more accurate in rate. There are many different proposed systems for fingerprint recognition based on image, neural and fuzzy approach. The proposed Support Vector Machine utilising Binary Decision Tree (SVM-BDT) based IFR algorithm is practical for fingerprint recognition. The basic idea is to extract by the number of end points and bifurcation points. A more logical approach is to extract the coordinate of distinct feature points and angle of their points according to their furrow pattern of fingerprint. This system illustrates the processing by considering elementary geometric terms and statistical computation. This system checks all of the features for input fingerprint image. Finally, the input fingerprint image features and fingerprint features in database are matched and the output result is given out.

2. RELATED WORKS

In biometric, there are various matching methods for effectiveness of recognition results. B.C Seow proposed that verification system may be applied directly on grey level image[4]. M.V. karki [6] proposed minutiae count and direct angle difference between minutiae point pair. Fingerprint verification using Gabor Co-occurrence features has been proposed by S.Arivazhagan. For fingerprint verification, Gabor Walet Transform (GWT) algorithm [5] is used in this approach. Euclidean distance between fingers codes is considered to match. Aliaa A.A. Youssif has proposed a fingerprint recognition system. Hybrid method [5] based on a minutiae-based and correlation based is used in this system. In conclusion, the author suggests that hybrid method can perform better than the individual method. J.Yang and J.W.Shin[3] showed an global minutiae and invariant moments that used the feature extraction and matching. These features vector contained radial distance, radial angle, minutiae direction and minutiae type. According to F.P.S Falguers, A.N. Marana and J.R.FaIFalguera they represented the fusion of a minutiae-based and a ridge-based fingerprint recognition method [1]. The objectives of the paper are to overcome the weakness and improve the accuracy rate. Gjorgji Madzarov, Dejan Gjorgjevikj and Ivan Chorbev proposed novel architecture of Support Vector Machine classifiers utilizing binary decision tree (SVM-BDT) for solving multiclass problems[2].

3 INTELLIGENT FINGERPRINT RECOGNITION SYSTEM

Local ridge characteristics called minutiae points represent the fingerprints. The conventional methods have utilized this minutiae information only as a point set and found out the matched points only from minutiae sets. As a global feature, orientation field provides robust discriminatory information other than traditionally used minutiae points. Intelligent Fingerprint Recognition System (IFR) using statistical and geometric approach to extract global features of the fingerprints and operates in three stages: (1) Minutiae matching (2) Reconstructed orientation field matching and (3) Fusion matching. In the first stage, true minutiae points are extracted from the input fingerprint image using an improved version of the extraction technique and the matching process is performed. In the next stage, the fingerprint's orientation field is reconstructed from the extracted minutiae and further utilized in the matching stage. The final stage employs a Decision - level fusion matching scheme which combines the reconstructed orientation field matching with the minutiae-based matching. Thus by using this scheme, performance of the system can be enhanced and better matching accuracy can be obtained than that of using conventional matching.

4.SVM-BDT Based Intelligent Fingerprint Recognition System

The proposed system mainly consists of four components: (i) image acquisition module, (ii) template database, (iii) enrolment module, and (iv) identification module. The system block diagram is shown in figure 1. The image acquisition module is responsible for acquiring fingerprint images of a user who intends to access the system. The template database is a physical database which contains all the template records of the users who are enrolled in the system. The task of the enrolment module is system management which includes user enrolment, user deletion, user update, training, system parameter specification, etc., Each enrolled user is represented by a record which contains the profile of the user and a number of representative fingerprint templates. For the fingerprint images, a minutiae extraction algorithm is applied and the minutiae patterns, which are the commonly used representation of fingerprints, are extracted. The flow diagram of a proposed method is shown in [Fig.1].

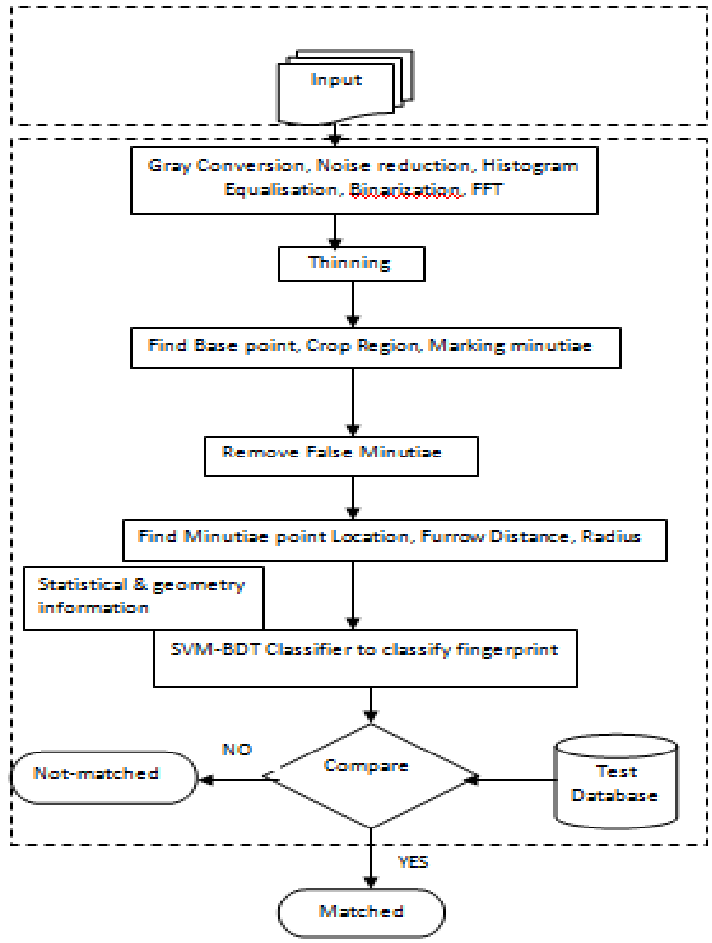

Figure.1 Flow diagram of Proposed IFR system

First the fingerprints are classified by Support Vector Machine classifiers utilizing binary decision tree (SVM-BDT) approach. The recent results in pattern recognition have shown that support vector machine (SVM) classifiers often have superior recognition rate in comparison to other classification methods. The popular methods for applying SVMs to multiclass classification problems usually decompose the multi-class problems into several two-class problems that can be addressed directly using SVM-BDT.
Then the fingerprint is processed by considering elementary geometric terms and statistical computation approach. This system checks all of the features for input fingerprint image. Finally, the input fingerprint image features and fingerprint features in database are matched and the output result is given out.

A. Preprocessing Steps

The performance of feature extraction for image depends on the quality of input image. To obtain the higher accuracy performance, the input image is made by enhancement technique. Several serious problems (ie. non-uniform noise, sensitivity of the fingerprint live scan device, extra-dry skin, cuts, aging, etc) are occurred in the fingerprint recognition process. In ***IFR*** system, Pre-processing Step is the most important than the other recognition system.

B. Image Enhance men

The enhancement function plays a basic role in image recognition to extract image features. We can use the enhancement technique to control the brightness of input image. The input pattern is distorted by various noises such as impress pressure, skin condition, and scanning device noise, etc. The ridges and furrow pattern of fingerprint image are located in a smalI neighborhood region. It also needs to define location of their points correctly. In our system, five methods are implemented for image enhancement.

- Gray scale conversion
- Noise reduction
- Histogram equalization
- Binarization
- Fourier transform

C. Thinning

An important approach to representing the structural shape of a plane region is to reduce it to a graph. Thinning is to eliminate all the ridges in a fingerprint to be one pixel thick. Thinning causes undesired spikes and breaks.

5. STATISTICAL AND GEOMETRICAL CALCULATION

A. Crop Region

Crop region is defined as the interest region (w x w) around base point of input fingerprint image. The width of interest region of image is depended on the resolution of the input image. In this system, the interest region has been considered on the number of same pixels around the base point shown in [Fig.2].

Figure.2 Base Line and Cropped Region

B. Base Line and Base Point

The maximum curvature of the concave ridges is defined as the base line and base point. The coordinate of this point is represented as (x_o,y_o). The base line is horizontal line across base point. In addition, the base point is used to align input fingerprint and enrolment fingerprint. The rotation metrics is used to align the input image and template image. The purpose of fingerprint alignment is to make both images exist on the same orientation.

$$R=\begin{bmatrix} \cos(\Delta\alpha) & \sin(\Delta\alpha) \\ \sin(\Delta\alpha) & \cos(\Delta\alpha) \end{bmatrix} \qquad (1)$$

Where, α is the difference orientation between the template image and input image.

C. Minutiae Marking

The Crossing Number (CN) is used to extract minutiae points. Rutovitz's definition of crossing number for pixel p is,

$$C(p) = \left(\frac{1}{2}\right)\sum_{i=1}^{8}|p_i - p_{i+1}| \qquad (2)$$

Where P(i) is neighbourhood of P which has binary value 0 or 1.

Figure.3.Ridge Ending points

Figure.4 Ridge Bifurcation Points

For each 3x3 windows, if the central pixel is 1 and C_n(p) =3 or three one value neighbours correspond to bifurcation. If the central pixel is 1 and C_n(p) = 1 or one values neighbour correspond to termination point. After applying image enhancement steps, the possible termination and bifurcation features

6.SUPPORT VECTOR MACHINE CLASSIFIER

A 2-class SVM model is built using sets of minutiae correspondences from fingerprint pairs known to belong to the same and different users. For a test pair of fingerprints, a similar set of minutiae correspondences is extracted and given to the recognizer, using only those classified as genuine matches to calculate the similarity score, and thus, the matching result.

For a binary problem, we have training data points: $\{\mathbf{x}_i, y_i\}$, i=1,...,l , $y_i \in \{-1, 1\}$, $\mathbf{x}_i \in \mathbf{R}^d$. Suppose we have some hyper plane which separates the positive from the negative examples (a “separating hyper plane”). The points **x** which lie on the hyper plane satisfy $\mathbf{w}\cdot\mathbf{x} + b = 0$, where **w** is normal to the hyper plane, $|b|/||\mathbf{w}||$ is the perpendicular distance from the hyper plane to the origin, and $||\mathbf{w}||$ is the Euclidean norm of **w**. Let d_+ (d_-) be the shortest distance from the separating hyper plane to the closest positive (negative) example. Define the “margin” of a separating hyper plane to be $d_+ + d_-$. For the linearly separable case, the support vector algorithm simply looks for the separating hyper plane with largest margin. This can be formulated as follows: suppose that all the training data satisfy the following constraints:

$$X_i \cdot w + b \geq +1 \text{ For } y_i = +1 \quad (3)$$

$$X_i \cdot w + b \leq -1 \text{ for } y_i = -1 \quad (4)$$

These can be combined into one set of inequalities:

$$Y_i (X_i \cdot w + b) - 1 \geq 0 \quad \text{for all } i \quad (5)$$

7. SUPPORT VECTOR MACHINE UTILIZING BINARY DECISION TREE

Support Vector Machines utilizing Binary Decision Tree, takes advantage of both the efficient computation of the tree architecture and the high classification accuracy of SVMs. Utilizing this architecture, *N*-1 SVMs needed to be trained for an *N* class problem, but only at most $|\log_2 N|$ SVMs are required to be consulted to classify a sample. This can lead to a dramatic improvement in recognition speed when addressing problems with big number of classes. An example of SVM-BDT that solves a 7 – class pattern recognition problem utilizing a binary tree, in which each node makes binary decision using a SVM, is shown on Fig. 5. The hierarchy of binary decision subtasks should be carefully designed before the training of each SVM classifier. The SVM-BDT method that we propose is based on recursively dividing the classes in two disjoint groups in every node of the decision tree and training a SVM that will decide in which of the groups the incoming unknown sample should be assigned. The groups are determined by a clustering algorithm according to their class membership.

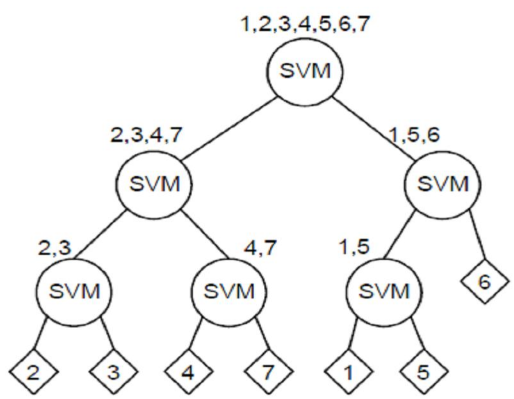

Figure.5 Illustration of SVM-BDT.

The SVM-BDT method that we propose is based on recursively dividing the classes in two disjoint groups in every node of the decision tree and training a SVM that will decide in which of the groups the incoming unknown sample should be assigned. The groups are determined by a clustering algorithm according to their class membership.

Let's take a set of samples $x_1, x_2 \ldots x_M$ each one labeled by $y_i \in \{c_1, c_2 \ldots c_N\}$ where *N* is the number of classes. SVM-BDT method starts with dividing the classes in two disjoint groups g_1 and g_2. This is performed by calculating *N* gravity centres for the *N* different classes. Then, the two classes that have the biggest Euclidean distance from each other are assigned to each of the two clustering groups. After this, the class with the smallest Euclidean distance from one of the clustering groups is found and assigned to the corresponding group. The gravity centre of this group is then recalculated to represent the addition of the samples of the new class to the group. The process continues by finding the next unassigned class that is closest to either of the clustering groups, assigning it to the corresponding group and updating the group's gravity centre, until all classes are assigned to one of the two possible groups. This defines a grouping of all the classes in two disjoint groups of classes. This grouping is then used to train a SVM classifier in the root node of the decision tree, using the samples of the first group as positive examples and the samples of the second group as negative examples. The classes from the first clustering group are being assigned to the first (left) sub tree, while the classes of the second clustering group are being assigned to the (right) second sub tree. The process continues recursively, until there is only one class per group which defines a leaf in the decision tree.

8. MINUTIAE MATCHING

To compare two fingerprints' orientation field, the first step is alignment of these two fingerprints. The Hough transform based approach has been chosen to finish the alignment due to its simplicity. In the matching step, the correlation between two aligned orientation fields, A and B, is computed as below. Let Ω denotes the intersection of the two effective regions after alignment, and N is the total number of points in Ω. The matching score between two orientation fields is defined as

$$s(A, B) = \frac{1}{N} \sum_{(i,j) \in \Omega} \delta(i, j) \quad (6)$$

In (6), $\delta(i,j)$ is the difference between the orientation values at the point, (i, j) in image A and B, which is formulated as follows:

$$\delta(i,j) = \begin{cases} \delta_o(i,j), & \text{if} \quad \delta_o(i,j) \leq \frac{\pi}{2} \\ \pi - \delta_o(i,j), & \text{otherwise} \end{cases} \quad (7)$$

and δ_0 (i, j) is defined as

$$\delta_o(i,j) = |\theta_A(i,j) - \theta_B(i.j)| \quad (8)$$

Here $\theta_A(i,j)$ and $\theta_B(i.j)$ are the direction of point, (i, j), in image A and B. If the matching score s (A, B) is higher than a certain threshold, we say the two orientation fields are "matched."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.

9 .RESULTS AND DISCUSSIONS

For performance analysis, the four distinct fingerprint databases are considered to establish the true minutiae. In this project, 150 samples were taken as input which consists of Arch, tented Arch, Whorl, Right loop and Left loop type of fingerprints. 100 samples were taken for test, 80 samples were trained and 20 remain untrained. The acceptance rate is calculated based on the recognition rate of untrained samples. The improvement in acceptance rate is analysed by comparing the existent fingerprint recognition technique with the Proposed SVM based Fingerprint Recognition using geometry approach.

A. Comparison of Results:

The database set contains four distinct databases (1) DB I_A, (2) DB 2_A, (3) DB 3_A, (4) DB 4_A. Each database consists of 100 fingerprint images (i.e.20 persons, 10 fingerprints per individual). The performance of a fingerprint classification system is usually measured in terms of acceptance rate or error rate. The acceptance rate is computed as the ratio between the number of correctly classified fingerprints and the total number of samples in the test set. The comparison of existent fingerprint recognition system with the SVM based fingerprint recognition system yields accuracy rate of 94%, 92%, 91% and 90% in comparing with 89%, 88%, 87% and 85% yielded by existent fingerprint recognition method for four distinct set of databases.

Table.1Performance comparison of proposed

DATABASES	DB1_A	DB2_A	DB3_A	DB4_A
Existing IFR	89%	88%	87%	85%
SVM based IFR	94%	92%	91%	90%

identification system with existing IFR system

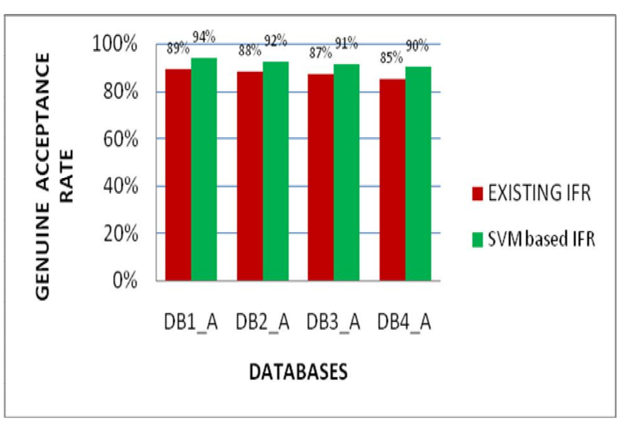

Figure. 6 Comparison of Genuine Acceptance Rate (GAR) for SVM based recognition method with existent method

10 CONCLUSION

Thus, a fast and robust approach to fingerprint recognition has been proposed. Orientation field is important for fingerprint representation. In order to utilize the orientation information in automatic fingerprint recognition system which only stores minutiae feature, a geometry method has been proposed to utilize the minutiae for fingerprint recognition. The reconstructed, classified orientation field information has been utilized into the matching stage. In order to improve the acceptance rate of fingerprint recognition, Support Vector Machine classifier utilizing Binary Decision Tree (SVM-BDT) is used. The proposed algorithm uses the interpolation method to reconstruct orientation field, and reduces the effect of false minutiae. The main benefit of this scheme is that it improves the verification performance to a large extent and it is effective for poor quality fingerprints or incomplete fragments of fingerprints. Hence the proposed scheme is more accurate and reliable than existing methods for real time applications.

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