A NEW FINGERPRINT IDENTIFICATION APPROACH BASED ON SVD FEATURES.

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ABSTRACT

Our objective is to apply the theory of linear algebra called singular value decomposition (SVD) and a set of invariant moment features to fingerprint images identification. For optimal recognition, we proceed in two steps. In the first step, we begin by identifying the fingerprint feature with SVD approach and invariant moment. In the second step, the classification accuracy of the proposed approach is evaluated with absolute distance classifier. I have implemented many extensive experiments, they prove that the fingerprint identification based on Invariants Moments and SVD features give better results than several other features and methods.

***Index Terms*—** Absolute Distance, SVD , Fingerprint, Invariant Moment.

1. INTRODUCTION

Fingerprint classification is currently a hot research topic in the pattern recognition communities. However, despite increasing attention from academic institutions, the fingerprint classification problem is far from being solved. Several systems that base their classification only on singularity features, is the detection of core and delta points. Since singularities are local features, they are very sensitive to noise [1].

Also, systems that are based solely on singularity features perform very poorly on noisy images, since the singularities are not always extracted reliably [1]. Some classification systems overcome these limitations by using both local (singularities) and global (ridge structures) features [1], but these approaches are insufficient. The classification with neural networks is also one of the most active research and application areas.

Neto and Borges have developed a neural network classification system that uses wavelet features [2], however, wavelet-based representations are not very useful for fingerprint classification due to their sensitivity to rotations and translations. Balti et al. [3] have used a feed-forward neural network with a single hidden layer was trained to classify feature vectors. However, due to the limitations of the feature set, the results from this system are not very impressive [1].

In this paper , we apply the theory of singular value decomposition (SVD) [4] and invariant moment [5] to fingerprint image verification. The SVD is used in many specific areas of digital image processing, image compressor, face recognition, and it is used very well for reducing the amount of data. The use of singular values of such refactoring allows us to represent the image with a smaller set of values, which can preserve useful features of the original image, but using less storage space in the memory, and achieving the fingerprint image features characterization process. The invariant moments are one of the principal approaches used in image processing to describe the texture of a region [4,5]. The seven moments used in this paper are invariant to translation, rotation, and scale changes, so they are able to handle the various input conditions [4,5].

In this paper, we propose a fully automatic matching approach which can reliably identify persons from these fingerprints. This new method is based on seven invariant moments and SVD features. The verification between the feature vectors of a test fingerprint and those of a template fingerprint is evaluated by absolute distance.

The fingerprint characterization and identification are investigated and tested, the experiments with seven invariant moments and SVD features are performed, it is used to overcome the demerits of traditional minutiae based methods and other fingerprint image based methods.

The remainder of this paper is organized as follows: the proposed fingerprint identification algorithm is briefly reviewed in section 2. The experimental results with absolute distance and the robustness of the proposed method are shown in section 3. Finally, we conclude in section 4.

2. PROPOSED FINGERPRINT IDENTIFICATION ALGORITHM

To overcome the many problems mentioned above, we propose a new SVD feature approach using seven invariant moments. Our proposed extraction feature and identification process are detailed in the following general flowchart, figure 1.

3. FINGERPRINT IDENTIFICATION RESULTS

The fingerprint image database used in this experiment is the FVC2002 fingerprint database [6], which contains four distinct databases: DB1_a, DB2_a, DB3_a and DB4_a.

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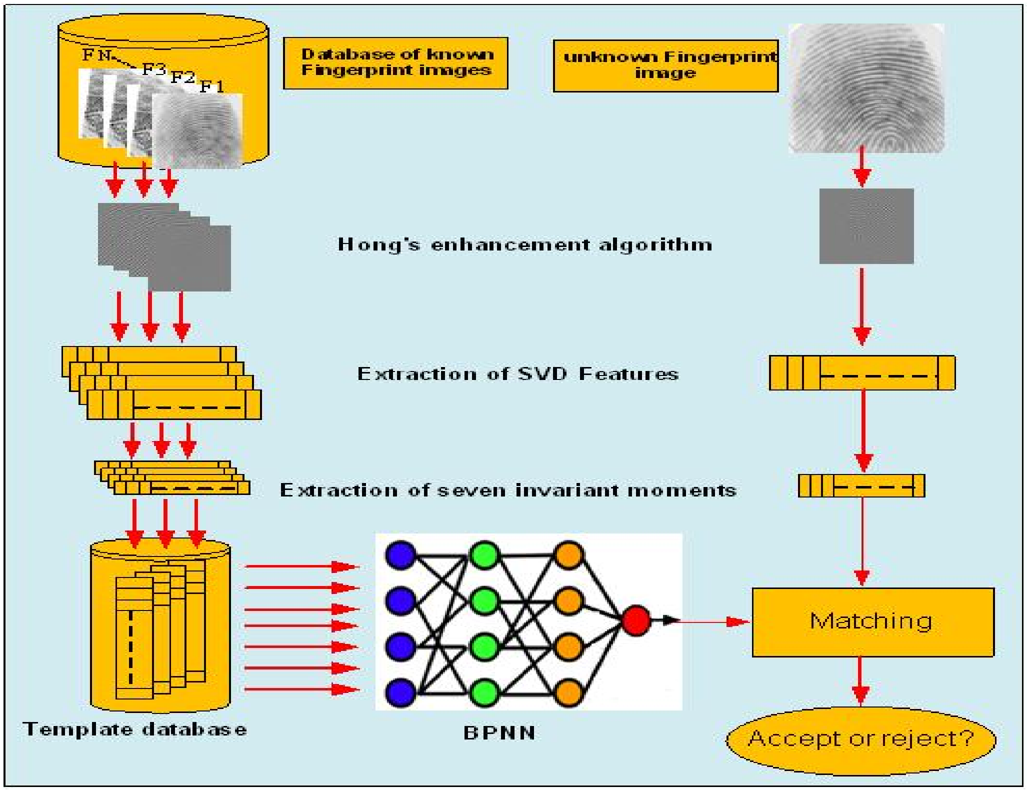

Fig. 1. General flowchart of a fingerprint recognition system

3.1 The performance evaluation

The Equal Error Rate (EER), False Reject Rate (FRR) and False accept rate (FAR) are computed on the four databases and the accepted fingerprint match (genuine) and the rejected fingerprint match (impostor) that is performed. For genuine fingerprint match, each test fingerprint of each person was compared to the template fingerprint of the same person. For impostor fingerprint match, the test fingerprint of each person was compared to the template fingerprint of other persons.
In order to examine the performance of the proposed meth od, two matching methods, proposed in references [7-8] were selected for comparison. First, method of Cheng Yang [7]: Proposes a fingerprint verification system based on invariant moment features and nonlinear BPNN. Seco nd, method of Amornraksa [8]: Proposes the fingerprintm atcher uses DCT features. the both methods were compare d with the same parameters as in their papers. The absolut e distance and BPNN were used as the matching metho d in this experiment.

3.2 SVD feature robustness with Frobenius matrix norm

Consider a set of eight different fingerprint images, extracted from the FVC 2002. In order of further highlight the practical applicability of the proposed characterization approach with SVD features. we have implemented and tested its robustness on fingerprint images corrupted by a salt and pepper noise and rotated by 90 degree, Figure 2. To check the robustness of the SVD feature vector, we propose to evaluate the characterization degree of the proposed method with the Frobenius norm. The experiment of the characterization degree is detailed in the following.

The Frobenius matrix norm is presented in several control problems such as comparison signal or image because the variations on a matrix can be seen as variations on the singular values. The Frobenius norm, is defined as the square root of the sum of the absolute squares of the elements of matrix A with size $m \times n$ and is donated by $\| \cdot \|_F$. The Frobenius norm can also be considered as a vector norm. It is also equal to the square root of the matrix trace of $A^t A$ where A^t is the conjugate transpose of A ($A \in C^{m \times n}$) , $C^{m \times n}$ is a vector space of dimension $m \times n$. The Frobenius norm of the matrix A is described as fellow:

$$\|A\|_F = \sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} \left|a_{ij}\right|^2} = trace\left(A^t A\right) \qquad (1)$$

The Frobenius norm can be calculated using the matrix singular value decomposition SVD.

$$\|A\|_F = \sum_i \sigma_i^2 \qquad (2)$$

Where σ_i are the singular values of A .

Invariant SVD feature vector are one of the principal approaches used in image processing, to describe the robustness of the proposed method . The Frobenius norm used in this experiment are invariant to translation, rotation, and noise of the input fingerprint images, so they are able to handle the various input conditions.

This experiment contains the stage of testing the robustness of the input fingerprints, randomly corrupted by rotation and noise.

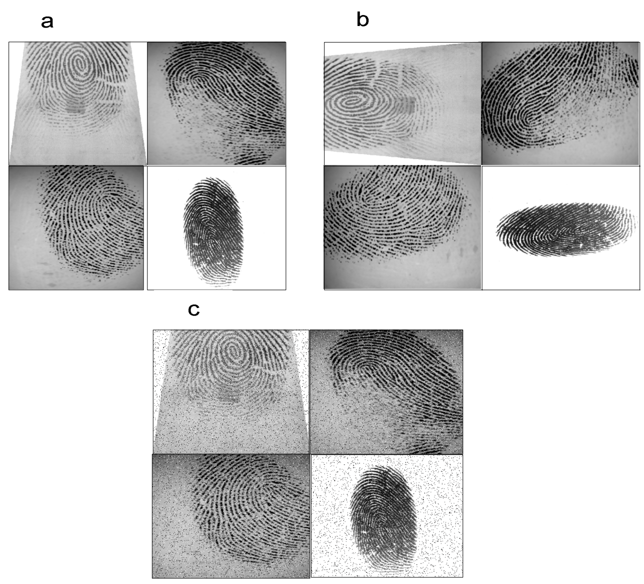

Fig.2 Samples of synthetic fingerprint image set used in the comparison of the characterization by SVD features. (a) Original image. (b)–(c) Results of, respectively; fingerprint image rotated by 90 degree, fingerprint image corrupted by a "salt and pepper" with SNR=10.14 dB.

A comparison study of characterization performance results is made with the Frobenius matrix norm Figure 15. For an in-depth study of the characterization capability of the proposed approach, we compute the Frobenius matrix norm based on the ratio between the Frobenius norm of the original feature vector and the Frobenius norm of vector projection presented in equation 25 for each original fingerprint images, images rotated by 90 degree and images corrupted by a "salt and pepper".

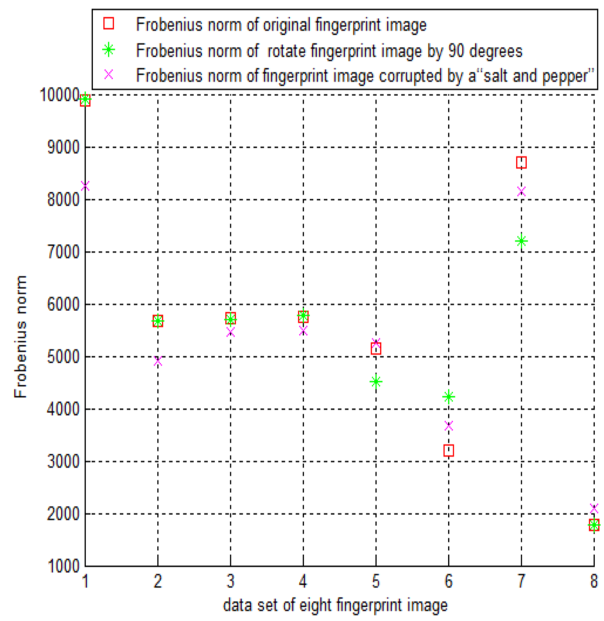

Fig.3 Frobenius norm of proposed SVD feature vector for eight fingerprint image

Our method is insensitive to nonlinear deformation and noise. Obviously, ridge counts are invariant, with respect to nonlinear deformation. In addition, our ridge count estimation method is more robust than that presented in other method. So, the proposed SVD feature vectors gives a compact and rotation invariant representation that is important for robust fingerprint indexing.

3.3 Fingerprint identification with absolute distance

Absolute distance is used to measure the similarity rate between the feature vectors of the input fingerprint with those of the template fingerprint stored in the database.

We define ϕ_i the invariant feature of the input fingerprint and $\phi_i^{\,t}$ the feature vector of the templates fingerprint stored in the database. ϕ and ϕ^t denote the invariant feature vectors of the two fingerprints to matched. V_d denote the difference vector of the two fingerprint feature vector, V_d is computed as in 3:

$$V_d = \left(\frac{\left|\phi_1^t - \phi_1\right|}{\max\left(\phi_1^t, \phi_1\right)}, \frac{\left|\phi_2^t - \phi_2\right|}{\max\left(\phi_2^t, \phi_2\right)}, \ldots \frac{\left|\phi_7^t - \phi_7\right|}{\max\left(\phi_7^t, \phi_7\right)} \right) \tag{3}$$

We define the absolute distance D_{abs} of the two matching invariant feature vectors as in 4:

$$D_{abs} = \sum_{i=1}^{7} \frac{\left|\phi_i^t - \phi_i\right|}{\max\left(\phi_i^t, \phi_i\right)} \tag{4}$$

From the figure 4 , we can find that the average EER (%) values of absolute distance matching over four databases with our proposed method is 3.92% , on the other side, the average EER (%) with method of Cheng Yang is 4.90%.

For a comparison study, our proposed method compared to the Cheng Yang method, the verification performance of our proposed method gives an Equal Error Rate (EER) lower than method of Cheng Yang. So, our proposed method performs a better accuracy.

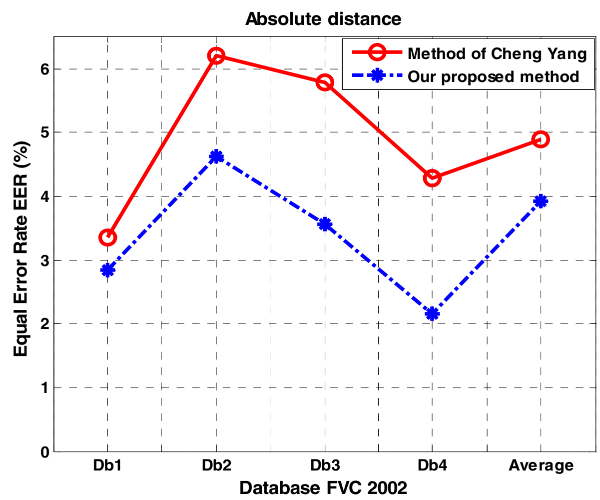

Fig. 4. Illustrates of the matching performances of the proposed method with the absolute distance over the four databases, using the comparison of the Equal Error Rate EER(%).

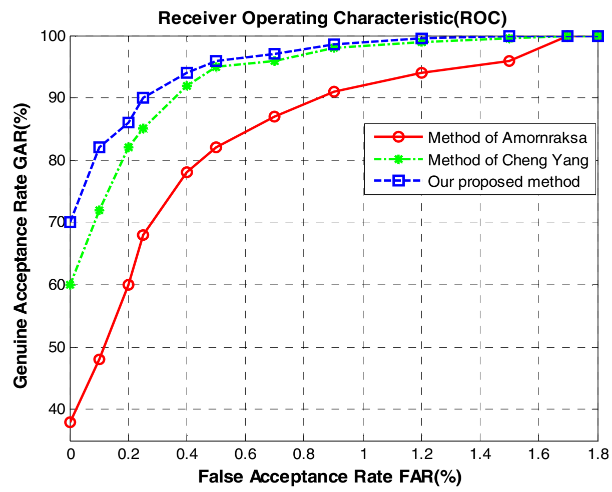

Fig.5 ROC plot comparing the proposed method with methods of Cheng Yang and Amornraksa on database FVC2002 DB1_A.

Figure 5 shows the ROC plot of the proposed method with the Cheng Yang method and Amornraksa method on database FVC2002 DB1_A. For the experiments, as shown in the figure 5, It is obvious that the proposed method is better than Cheng Yang and Amornraksa methods. So, The proposed method characterized by robust performance and greater matching accuracy than other methods.

4. CONCLUSION

In this paper, a fingerprint verification system based on invariant SVD feature is proposed. The matching rate between the feature vectors of a test fingerprint and those of a template fingerprint in the database is evaluated by a Back Propagation Neural Network (BPNN) and its performance is compared to other methods as absolute distance. Using BPNN as a verifier may provide the flexible system with high matching accuracy. The comparison results show that the proposed method outperforms them in verification accuracy.

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