Support Vector Machine Based Fingerprint Identification

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***Abstract*—This work is released in biometric field and has as goal, development of a full automatic fingerprint identification system based on support vector machine. Promising Results of first experiences pushed us to develop codification and recognition algorithms which are specifically associated to this system. In this context, works were consecrated on algorithm developing of the original image processing, minutiae and singular points localization; Gabor filters coding and testing these algorithms on well known databases which are: FVC2004 databases & FingerCell database. Performance Evaluating has proved that SVM achieved a good recognition rate in comparing with results obtained using a classic neural network RBF.**

Keywords—Biometry, Core and Delta points Detection, Gabor filters coding, Image processing and Support vector machine.

I. Introduction

Fingerprint-based identification is one of the most important biometric technologies which have drawn a substantial amount of attention recently [1].

Fingerprints are believed to be unique across individuals and across fingers of same individual. Even identical twins having similar DNA, are believed to have different fingerprints [1]. A fingerprint is the pattern of ridges and valleys on the surface of a fingertip [2].

Fingerprint recognition can be categorized into identification and verification. Fingerprint identification is the process of determining which registered individual provides a given fingerprint. Fingerprint verification, on the other hand, is the process of accepting and rejecting the identity claim of a person using his fingerprint.

Fingerprint recognition can also be categorized into minutiae extraction based and spectral features of the image based.

All technologies of fingerprint recognition, identification and verification, minutiae extraction based and spectral features based, each has its own advantages and disadvantages and may requires different treatments and techniques. The choice of witch technologies to use is application specific.

II. How Fingerprint Identification Works

At the highest level, all fingerprint recognition systems contain two main modules *feature extraction* and *feature matching*. Feature extraction is the process that detects singular and all other minutiae points (see Fig. 1) from the original image that can later be used to represent each fingerprint. Feature matching involves the actual procedure to identify the unknown person by comparing extracted features from his/her fingerprint with the ones from a set of known persons. We will discuss each module in detail in later sections.

Although fingerprint authentication appears to be an easy authentication method in both how it is implemented and how it is used, there are some user influences that must be addressed.

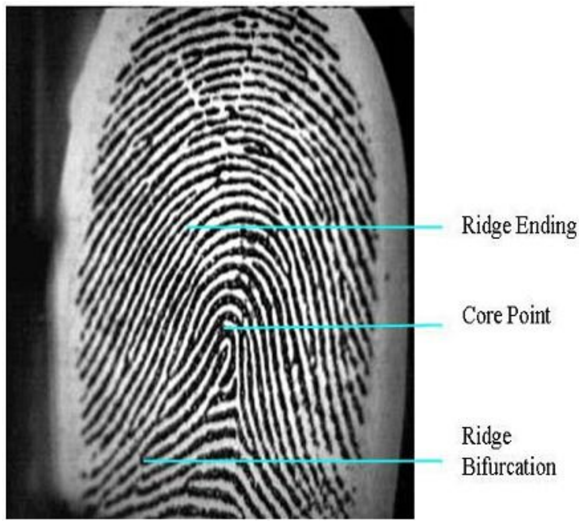

Figure 1. Ridge ending, core point and ridge bifurcation are shown [1].

Influence of several fingerprint image quality characteristics on the performance of the verification system [3].

The displaced, false or missing singular points [2].

Background noises will interfere with the user who is trying to authenticate to the device. The environment in which the user is authenticating to the device must be free of any major background noise [4].

III. PROPOSED DESIGN

The problem of fingerprint recognition is one of much broader topics in scientific and engineering so called pattern recognition. The goal of pattern recognition is to classify objects of interest into one of a number of categories or classes [4]. The objects of interest are generically called patterns and in our case are images of fingerprints matrix called vectors codes or fingercodes that are extracted from an input image using the techniques described in the later section. The classes here refer to individual person. Since the classification process in our case is applied on extracted features, it can be also referred to as feature matching.

This article demonstrates how fingerprint identification can be released with SVM as matching process, but before that, the minutiae image of the fingerprint has to be converted into a vector code, also called fingercode, by using Gabor filter bank [5].

IV. PROBLEM STATEMENT

A model of SVM is to be designed and trained to recognize the fingercode of the databases that are actually used. An imaging system that converts each fingerprint image in fingercode or minutiae matrix code by using a bank of Gabor filters (see Fig. 2). The result is that each fingerprint images is represented as a vector of 256 real values.

Creating a fingercode

Following steps are observed to create the fingercode:

1. Preprocessing of the image (to remove noise) by window wise normalization, Histogram Equalization, low pass and median filtering [6].

2. Core point location using max concavity estimation [7].

3. Tessellation of circular region around the reference point.

4. Sector wise normalization followed by application of bank of Gabor filters in the spatial domain which has general form as in (1) [8].

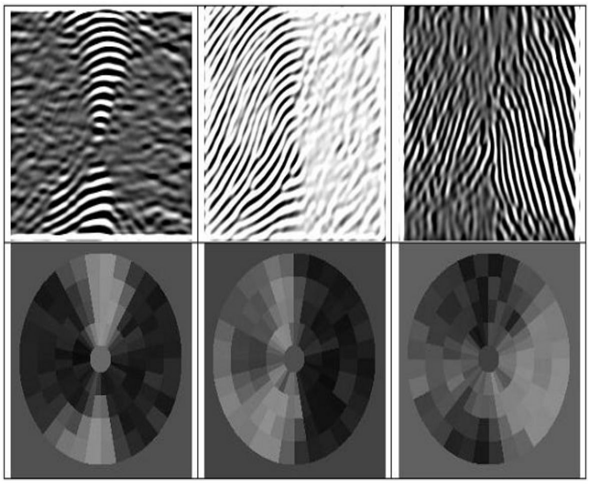

Figure 2. Filtered images and their corresponding feature vectors for orientations 0°, 5°. 22.5° and 45° are shown [1].

$$G(x, y; f, \theta) = \exp\left\{\frac{-1}{2}\left[\frac{x'^2}{\delta_{x'}^2} + \frac{y'^2}{\delta_{y'}^2}\right]\right\}\cos(2\pi f x') \qquad (1)$$

$$x' = x \sin\theta + y \cos\theta \qquad (2)$$

$$y' = x \sin\theta - y \cos\theta \qquad (3)$$

Where f is the frequency of the sine plane wave along the direction θ from the x-axis, and $\delta_{x'}$ and $\delta_{y'}$ are the space constants of the Gaussian envelope along X' and Y' axes, respectively.

5. Finally feature code generation by obtaining standard deviation values of all the sectors, [8].

V. FINGERPRINT RECOGNITION

In less than few seconds, even on a database of hundreds of records, the matrix of pixels generated from an image of fingerprint is compared to previously enrolled ones to see if it matches any of them. The decision threshold is automatically adjusted for the size of the search database to ensure that no false matches occur even when huge numbers of matrixes of fingerprints are being compared with the live one. Some of the bits in a matrix signify if some data is corrupted (e.g. the image of fingerprint has degraded by noise), so that it does not influence the process, and only valid data is compared. Decision thresholds take account of the amount of data, and the matching operation compensates for any tilt of the image of fingerprint. A key advantage of fingerprint recognition is its ability to perform identification using a one-to-all search of a database, with no limitation on the number of fingerprint records and no requirement for a user first to claim an identity, for example with a card. For our method we use and experiment SVM [9], which is used for matching and perform recognition using a one-to-all search of a database.

VI. EXPERIMENT AND TEST

A. Databases and datasets

To evaluate the performance of the proposed method, it is necessary to dispose a database of fingerprints representing the purchasing system. Unfortunately these databases are not always available immediately.

It is available from the National Institute of Standards and Technology [10] bases of several thousand prints. These images were scanned from prints identity papers obtained by the traditional method of ink, they are very poor quality. To compare different methods of treating them, a competition was held to assess the performance of algorithms from the same images [11]. The databases are used openly and from three different sensors trade.

These databases are used in our case despite the acquisition systems used can rotate finger any angle. This is not the case in our system (assumption the existence of a guidance system).

Our system was tested with four databases of FVC2004 and FingerCell database.

To effectively represent the performance of the dataset's size should be large enough [12], but the number of images is large and the duration of the tests is very long. For practical reasons we are constrained to a bank of 152 images with 19 different sets of fingers, each dataset consisting of 8 images in the case of FVC2004 corresponding to various acquisitions of the same finger and in the case of FingerCell, a bank 190 images with the same number of different sets of fingers, but a different number of pictures related to various acquisitions of the same finger (10 images).

B. Results

Table 1 shows the results of recognition rate and performance of the proposed system.

TABLE 3. RECOGNITION RESULTS ON THE PERSON'S FINGERPRINT DATABASES (OF FIVE DATA-SETS) ON A PC WITH 3.0 GHZ PROCESSOR.

Datasets	**Time for Train (s)**		**Time for Test (s)**		**Recognition Rate (%)**	
	RBF	**SVM**	**RBF**	**SVM**	**RBF**	**SVM**
FVC2004 DB1	2,26	32,09	71	1,37	63.1	68.4
FVC2004 DB2	1,04	17,46	29	1,12	63.1	63.1
FVC2004 DB3	2,89	18,29	107	0,90	68.4	73.6
FVC2004 DB4	1,04	17,81	31	1,05	68.4	78.9
FingerCell	23,6	4,50	47	0,92	89.4	94.7

Results obtained with SVM and RBF on five fingerprints datasets shows that recognition rates are much better using SVM. In the other hand, it is clear that that RBF is very slow in recognition stage in comparing with the other approach.

VII. CONCLUSION

Fingerprint recognition is a challenging problem and there is still a lot of work that needs to be done in this area. Over the past ten years, fingerprint recognition has received substantial attention from researchers in biometrics, pattern recognition and image processing communities. This common interest in fingerprint recognition technology among researchers working in diverse fields is motivated both by the remarkable ability to recognize people and by the increased attention being devoted to security applications.

Applications of fingerprint recognition can be found in security, tracking, multimedia, and entertainment domains. We have demonstrated how a fingerprint recognition system can be designed by a support vector machine, to capture the minutiae characteristics of fingerprint, the level of performance obtained with SVM is such that in a variety of tasks, processing architectures developed using SVM can perform at least as well and in many cases substantially better than more conventional image processing and pattern recognition techniques. [12]. By elucidating the computational principles which make this level of performance possible, it may well be possible not only to demonstrate the power of computational methods as a paradigm for understanding artificial intelligence, but may reveal the potential of the discipline in areas as diverse as machine vision and artificial intelligence.

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