AUTOMATIC BIOMETRIC IDENTIFICATION SYSTEM BY HAND GEOMETRY

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ABSTRACT

In this paper we propose a novel and simple method to recognize individuals based on their hand-palm geometry. A compact set of parameters has been extracted and reduced using different transformations. Two classification methods have been implemented: Neural Networks (NN) based on the commonly used Multilayer Perceptron (MLP) and the most nearby neighbor classifier (KNN). Results show that not complex algorithms are required in the classification phase to obtain high recognition values. In our simulations, rates beyond 99% have been achieved.

1. INTRODUCTION

Biometric identification systems have experimented an explosive growth in devices concerning with security applications; they lead a privileged position in the chosen methods used to identify or verify the identity of a user presented to the system. Among all existing methods, maybe the use of the geometry of the hand is actually one of the most investigated and employed ones due to their reliability, efficiency and facility to use [1][2].

The aim of our work is to develop a simple and effective recognition system to identify individuals using the palm of their hands. We are going to utilize simple and acquaintance classifiers as Neural Networks (NN) [3], and the most nearby neighbor classifier (KNN) [2].

The first step is to elaborate a database containing a set of characteristics from the users. This database has been built off-line, and contains 500 samples taken from 50 different users. Two main parameters are extracted from the user's hand-palm: geometrical and contour information.

The database is then pre-processed with the purpose to prepare the images for the parameter extraction phase. This process is composed by four main stages: binarization, contour and main points extraction (finger tips and valleys between fingers), area and perimeter calculation, and finally a contour normalization of the hand [4].

Contour information generated in the previous step is too large to be efficiently used and classified with the proposed methods in our system thereby it has to be reduced. Several techniques for reduction has been used and compared. The objective is to reduce the length of the features keeping as much information as possible; among these techniques we can find the simplest obtained by sub-sampling the feature space, image descriptors using a wavelet decomposition [5] or more advanced techniques as Principal Component Analysis (PCA) based on transform domain techniques.

We will classify both sets of features (geometric and contour based) using the two classifiers already commented: Neural Networks and the most nearby neighbor classifier (KNN). Comparison of which of the classification techniques are more suitable for every set of parameters can be drawn from the results.

In this paper, we, first, present how the database was elaborated and the image processing needed to be able to extract further parameters. Then details and procedures for extracting the features are shown. The classification process and results are presented in sections fourth and fifth. Finally in the last two sections conclusion and further references are given.

2. DATABASE ELABORATION AND IMAGE PROCESSING

In this section we describe the characteristics of the database, the steps performed in its realization and composition, and several pre-processing techniques utilized. The database is composed by 10 scanned hand samples taken from 50 different individuals. This database has been built off-line, the user has to be enrolled in the

Properties of the images contained in the database	
Size	80% original. size
Resolution	150dpi
Colour	256 gray levels
File size	1405 Kbytes
Data matrix dimension	1403x1021

Table 1: Image specifications.

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system before he/she can use it for the very first time. For the image acquisition, it has been utilized a desktop scanner with a resolution of 150 dpi, the original size of the hand has been reduced in a 20% to facilitate subsequent calculations and processes on the image. The main image specifications used in building the image database can be observed in the table 1.

As an example, Figure 1 shows a sample image taken from the database.

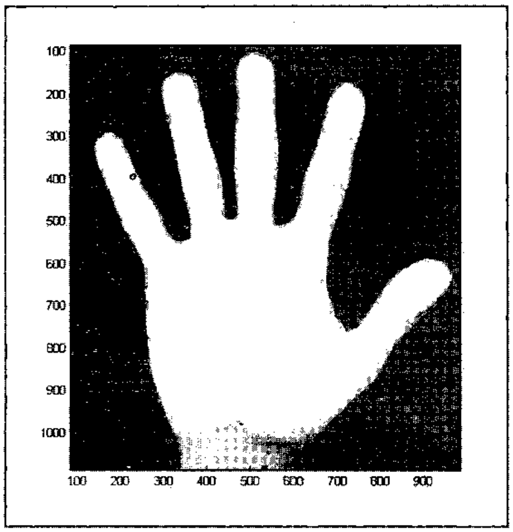
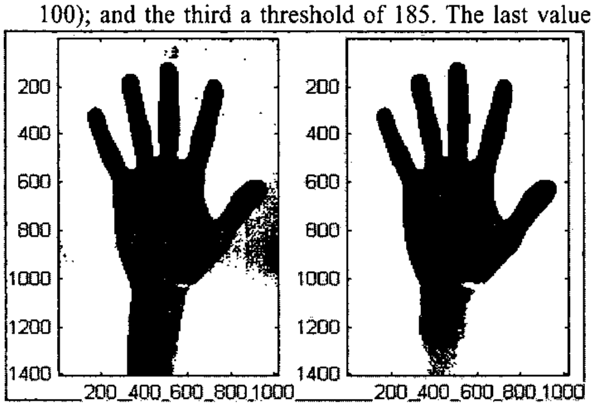


Figure 1. Hand Image extracted from the database.

Once the database is created, we should process it to transform the images into a suitable format to facilitate further parameter extraction. From the grey scale images we obtained a new image containing the contour or the outline of the hand. Two fundamental steps were followed to achieve these objectives:

- Binarization of the image: During the search of the optimum threshold, it has been proved different methods as the ones suggested by Lloyd, Ridler-Calvar and Outsu [6]. The two first algorithms gave us a threshold very similar (around value of intensity 100); and the third a threshold of 185. The last value totally was ruled out, since the processed image, once applied the threshold of 185 was worse than the case of high threshold shown in the Figure 2. For the value of 100 did not exist many differences, since small variations in the election of the threshold do not affect in an important way the final results. Therefore, the search of a threshold is a heuristic process resulting in a threshold place in the range of 65-100.
- Compute of the hand contour: Using the binarized image, we run through the hand silhouette by following the image's edge. The monitoring of the contour is a procedure which sweeps through the hand outline, distinguish between object (hand) and underground. The implemented algorithm is a modification of the algorithm created by Sonka, Hlavac and Boyle [7]. In the original algorithm, the authors use a description of the contour based on 4 values (0,1,2,3) to codify the direction of each point located in the contour of the hand. In our implementation, we have taken into account 8 possible changes of direction. The result of this process can be observed in the following figure;

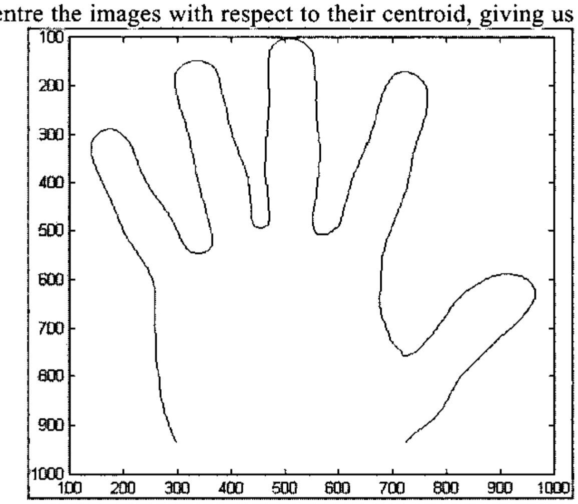


(a) High threshold *(b) Selected threshold*

Figure 2. Process of binarization.

Figure 3. Contour extracted of the binarizated image.

The last step in the pre-processing phase, it is to centre the images with respect to their centroid, giving us the desired translation invariance.



3. PARAMETER EXTRACTION

Different techniques have been undertaken to determine which ones provide higher identification rates. Two completely different sets of parameters are extracted from the images.

- Geometric Measurements: 10 direct features are extracted from every image: Length of the fingers, 3 hand ratio measurements, area and perimeter.

Figure 4 shows the geometric measurements graphically.

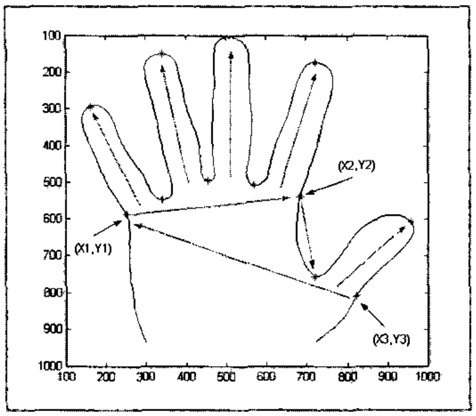


Figure 4. Contour and measurements extracted from the image taken as example.

- Contour information: Besides the direct information obtained from the hand. We can use extra information from the contour. In order to reduce the set of parameters we proposed to use a module representation of the contour (distance from the origin to every point in the contour). This process provides us with a wave shape signal (Figure 5) particular to every user.

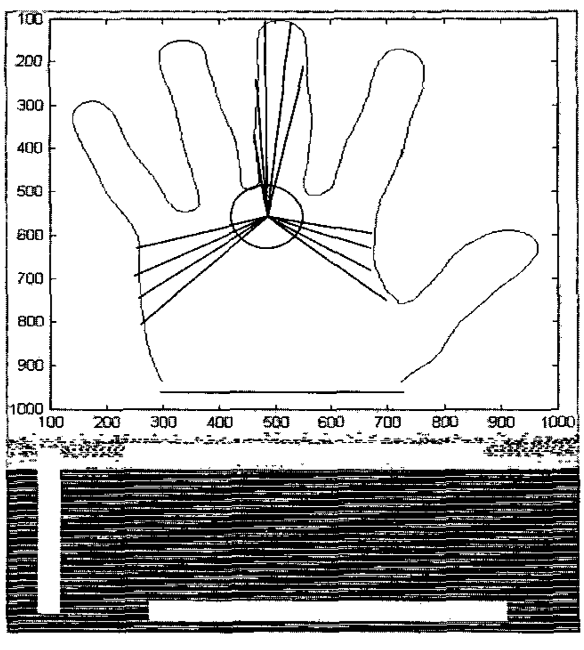


Figure 5.Outline of the hand and representation of the module.

Another form of parameterise has been from the contour of the hand, sweeping by polar coordinates (module and phase) [7]. A typical problem found when we use this technique is the length of template vector. Generally it is desirable to find or to reduce the set of characteristics, to one new vector that be minimum but sufficient. This it can be achieved by means of a judicious elimination, because the elements that compose this vector would be enough related between them. In order to reduce the length of template vector, the next techniques are:

- Principal Component Analysis (PCA) [3]: PCA also known as Karhunen Loeve transformation can be used to reduce the feature vector dimension while retaining the feature information by constructing a linear transformation matrix. The matrix of transformation is composed of the eigenvectors more significant of the covariance matrix, formed from the vectors of characteristics. The eigenvectors are orthonormals (orthogonal and normalized) therefore with them we will transform the original data in independent characteristics having maximum variance.
- Wavelet transform: Those transform are mathematical functions that divides the data in different components, and studies each component with an appropriate resolution to their scale. The advantage of Wavelet transformed on the traditional methods of Fourier is that it can analyse situations where the signal contains interruptions and abrupt peaks [8]. This discrete Wavelet transformed (DWT) is a lineal operation that generates a structure of data that contains $\log_2(n)$ variable segments of length.
- Cosine transform: Inspired in the idea of the descriptors of Fourier, we ask ourselves if any another transform could be used instead of the DFT to obtain better results. As it is known, the high information redundancy present in the images turns out to be ineffective when these images are used directly for tasks of recognition, identification and classification. To reduce this quantity of information we will use Discrete Cosine Transformed (DCT) as a way of compaction of the energy in the signal. As it can be known, Karhunen-Loève Transformed (KLT) is optimum transformed in terms of compaction of energy [4], the problem is that the KLT is clerk of the data and obtaining the base images of the KLT is in general a very high computational task. The DCT has interesting properties that can be taken as advantage [4][9], such as that possess an excellent property of compaction of energy for highly correlated data and it is a fast transform as the DFT.

Recognition rates were computed for the following features length: 128 and 512 values for sub-sampling, 50 and 128 values for PCA, and 128 and 512 values for wavelets. With this parameter extraction, the success rates in user identification are shown in Table 1. These experiments have been repeated 10 times, for averaging the rates, being shown the results of the maximum recognition rate, in function of the employed training percentage (see the table 1).

4. CLASSIFICATION

Two classifier methods have been utilised in our recognition system. In both cases, the learning was supervised, creating a two-phase process in the classification, the training and the test phase.

The neuronal network utilized is a feedforward one; being training with the system of learning perceptron multilayer (NNMLP)[3], by means of the algorithm back propagation. A hidden layer containing 58 neurons has been utilized giving us the best results.

Another utilized classifier method is the most nearby neighbour classifier (KNN)[2]. This algorithm is one of the simplest methods of classification. All in all, the portion of code of the algorithm stores the data that we present. When we want to do a prediction on a new one vector of characteristics, the KNN algorithm finds the vector more nearby (according to some metric distance) from the training vectors to the new vector, and predicts the new class. The KNN is a method of learning based on the most next neighbour. This algorithm calculates the similarity among the sample of test and the samples of training, considering the k vectors more nearby in the training, finding the class that more is seemed. To find the vector of more seemed training (not alone in distance), we use the method of the majority of votes.

The degree of similarity between two samples is the distance among them, based on a metric distance. In our simulations we have used the distance Euclidean.

Be t a sample with n characteristic represented by the vector of characteristics $< v_1(t), v_2(t), \ldots, v_n(t) >$ where the term $v_i(t)$ is the value of the characteristic one i of the sample t. Therefore the distance among two samples t_i and t_j are $d(t_i,t_j)$, where:

$$d(t_i,t_j) = \sqrt{\sum_{m=1}^{n} (v_m(t_i) - v_m(t_j))^2}. \qquad \text{Eq. 1}$$

5. EXPERIMENTS AND RESULTS

The realized experiments have been carried out according to each classifier, applying each one of the techniques cited previously (vector reduced and geometric parameters). It has been carried out varying the percentage of training, with the intention of utilising a number reduced of hands at the moment of to create the training, tried to discover which is the minimum. In the following table are shown the obtained results, expressing the rate of reached success, in function of the type of parameterization, classification method, length of the parameters and number of hand for training (like there is 10 hand, each hand is 10% of training).

		Maximum Recognition Rate			
Number of hand		3	5	7	9
Sub-Sampling	KNN-128	82,2%	87,92%	90,24%	90,46%
	NN-128	92,21%	96,2%	98%	99%
	KNN-512	91,25%	94,36%	95,26%	96,6%
PCA	KNN-50	88,22%	92,96%	94,93%	96,4%
	NN-50	92,11%	96,92%	98,4%	98,8%
	KNN-128	89,94%	94,32%	96,26%	97,6%
	NN-128	80,9%	89,76%	94,2%	97%
Wavelets	KNN-128	90,71%	94,28%	95,8%	97,6%
	NN-128	84,02%	92,92%	94,66%	96,2%
	KNN-512	90,77%	93,76%	96,46%	97,6%
Geometry Measurement	KNN-10	99,28%	99,56%	99,73%	100%
	NN-10	99,02%	99,56%	99,73%	99,8%

Table 1: Comparison between different techniques of identification.

6. CONCLUSIONS

A biometric identification system has been proposed for persons recognition based on the hand geometry, with a very high relation between simplicity and efficiency, since with 10 parameters we have obtained a recognition rate of the 100% with our database, using the most nearby neighbors classifier.

The rest of results are also appropriates, although it is obtained lower rate of success, with this, the rest of the method has good response, too, using both classifiers and varying the percentage of training.

7. REFERENCES

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