Neural Networks Applied to Fingerprint Recognition

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Abstract. In this paper we use a Multi-layer perceptron neural network with learning algorithm retropropagation errors, for application in fingerprint recognition. The objective is to measure the efficiency of the neural network by varying the test data. We observe the behavior of the network in the special case of a partial print. Once the overall structure of the network was designed, tested and properly trained, we proceeded with the testing process, varying the characteristic points and their particular characteristics. Overall, the results demonstrate a stronger recognition when all the characteristic points for the individual prints are available. The recognition rate begins to decrease as the number of characteristic points is reduced to 12, but increases when the number of points is 10, 8 or 5. We obtained a good percentage of hits to remove the features that depended on the center of the footprint and the footprint of the code, in this way to reach the desired goal.

Keywords: neural networks, fingerprint, recognition, identification.

1 Introduction

It should be noted that the traditional methods for reading and identifying key cards, have some shortcomings that make the information stored on the cards, including financial data, etc., more vulnerable to theft. This has resulted in significant development in biometric identification systems [1] [2]. Biometric identification systems are based on the detection of individual physical traits that are measurable. These features are captured by a system that automatically performs the recognition of the person and must meet the following conditions: universality (everyone should have that feature), uniqueness (must be unique for each individual), stay (invariable through time) and quantifiability (must be measurable in a quantitative manner).

The use of fingerprint biometric identification techniques is widely accepted because, in addition to meeting the previously mentioned conditions, it is highly reliable, easy to use, prevents against attacks, generally accepted, and reliable, it can be authenticated, is cost efficient and standardized [3].

This paper presents the use of an artificial neural network for identifying individuals through fingerprints. A data set was used that includes the characteristic points that were extracted from the fingerprints of several people through a specialized system.

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The effectiveness of an artificial neural network in the detection of fingerprint characteristics was evaluated by varying the number of points to identify for each fingerprint. The characteristics included: the distance between peaks of different points, the angle according to the center of the fingerprint, the position of the center point of the track, and the type of point pattern (abrupt, merger), among others. The decrease in the characteristics that were tested is due to the fact that there may be some special cases in which it is necessary to identify a print that, for any number of reasons, is incomplete.

2 Theoretical Concepts

2.1 Fingerprint

Biometry is the measurable or statistical study of biological phenomena or processes. Biometrics identification, involves seeking a physical trait, dactylogram, iris, etc. that endures over time, as opposed to behavioural attributes that can change more easily.

Fingerprinting is the study and observation of the papillary ridges and drawings that are on the inside of the hands and soles of the feet. A dactylogram differs in the peaks, fingertip lines, and the rows and spaces between those lines.

To determine whether one fingerprint matches another, it is necessary to observe the characteristic points of both samples. If the two tracks have the same points in the same places, it is possible to conclude that the two fingerprints are from the same person. Characteristic points can be defined as the particular circumstance or individual papillary ridges found on an exact location.

Statistically speaking, a minimum of thirty points for each characteristic fingerprint of a finger is considered normal, although the actual number varies by country. In Spain, ten to twelve characteristic points are considered sufficient. Digital identification systems typically look for two kinds of points and abrupt junctions, also called M [4] [5].

2.2 Neural Networks

An artificial neural network (ANN) is a computational model, or an information processing system, whose design is based on biological neural networks. It is capable of learning based on examples of adaptability, and is characterized by its robustness, fault handling and generalization capabilities. RNA is usually used in the process of classification, pattern identification, and mathematical modeling predictions [6] [7] [8]. One of the advantages of an ANN is its ability to handle non-significant changes in the information input signals with noise. The present study takes the benefits of RNA into account in order to implement a classification and fingerprint recognition.

3 Neural Networks Applied to the Detection of Fingerprints

There are currently several methods for detecting fingerprints using artificial neural networks [9] [10] [11]. In this study we will focus on the identification of fingerprints based on the increased use of characteristic points, which are certain characteristics that make fingerprints completely unique [12].

The present study was based on a data set of characteristic points of prints from various individuals. It should be noted that the image processing of the fingerprint was already carried out, and the data extracted from the image.

For the appropriate use of the information contained in the database on the artificial neural network, an initial analysis was conducted in order to determine which fields would be significant. Two tables were taken into consideration: "Malla" and "Punto_caracteristico". The former includes details of all the characteristic points that reference other points nearby, as well as the number of ridges between two points. The latter lists the characteristic points in full detail, i.e. its angle, position, etc. This established a relationship between the two tables, leaving only one file, which was used as a reference for training the neural network.

To determine the training data, different numbers of points and characteristics were tested. The features that remained after less data was taken into account are: Dis, Posición_x, Posición_y, Tipo punto, Codigo huella.

The system uses a Multi-layer perceptron architecture [13]. The retropropagation training algorithm was used for errors [14]. The sigmoid transfer function or activation was used in the hidden layers. A linear function was used for the output layer. The choice of the functions used for the hidden and output layers was the result of various tests.

The overall network consists of: 9 neurons in input layer, two hidden layers of 11 neurons each, and an output layer of 11 neurons. 9 neurons in the input layer represent the fingerprint characteristics: Dis, ang_direccion, posicion_x, posicion_y, Tipo_punto, Codigo_huella, N_crestas, Cuad_x y Cuad_y. The output layer is composed of 11 neurons, which include the people in the database. Each neuron in the output layer returns the value 0 or 1.

The results lost effectiveness when the hidden layers were increased to 3 and more than 15 neurons were allocated in these layers. Testing with two layers and 11 neurons in each one resulted in improved results.

4 Tests and Results

Four tests were generated. As a result, we were able to obtain four neural networks from the same data set, each one trained in different ways.

The four different neural networks were subsequently tested, varying the number of points. A hypothesis was raised, based on the fact that some features were introducing noise to the results. As a result, several tests were conducted in order to identify the characteristics that were producing this noise.

The characteristics that were taken into account for all the tests were: dis, posicion_x, posicion_y, tipo_punto y Codigo_huella. In each experiment, three of the four remaining features were added (ang_direccion, N_crestas, Cuad_x y Cuad_y) leaving out one identifying characteristic of the noise producer.

In Table 1 shows the result of the tests.

The above results would appear to indicate that as the characteristic points were reduced from 20 to 5, the success rate was adversely affected. But this is not entirely true because, the results in characteristic points with 10, 8 and 5, show an extremely high percentage of success. However the results are very similar to the total for all the characteristic points.

Table 1. Details of tests (success rate)

Características	121	20	18	16	14	12	10	8	5	%
Todas	86.77	75.00	72.22	75.00	71.43	75.00	90.00	87.50	80.00	79.21
Sin ang_direccion	86.77	75.00	72.22	75.00	71.43	75.00	90.00	87.50	80.00	79.21
Sin ang_direccion y sin N_crestas	86.77	75.00	72.22	100	71.43	75.00	90.00	87.50	80.00	81.99
Sin ang_direccion, sin N_crestas, sin Cuad_x, sin Cuad_y	77.68	70.00	66.67	68.75	64.29	58.33	80.00	62.50	80.00	69.80
Sin ang_direccion, sin N_crestas, sin Cuad_x, sin Cuad_y, sin codigo_huella	86.77	80.00	77.78	81.25	78.57	75.00	90.00	75.00	80.00	80.48

On the other hand, the results demonstrate that while decreasing the number of characteristics, the behavior of the neural network remains constant at about 80%, except in cases where the Cuad_x y Cuad_y features are deleted. However, when the fingerprint feature code is deleted, there is a huge improvement in network performance. Results indicate that removing all of those characteristics on the final test improves network performance, since those characteristics are not considered to be a highly important aspect in the classification of classes.

5 Conclusions

Artificial neural networks in the field of fingerprint detection are widely used. This paper implemented a specific case in which only a few characteristic points were available. The specifications or features of these characteristics are not dependent on the center of the print, as we assume that the neural network will detect an incomplete track. Taking the above information into account, the results were satisfactory, since there was an overall success rate of 80.48% in all tests where the four characteristics that depend on the center of the print were removed, and where the number of characteristic points was varied, while ignoring the code characteristics for each print.

References

1. Kresimir Delac, M.J.: A survey of biometric recognition methods. In: 46th International Symposium Electronics in Marine (2004)
2. Zhang, Z., Fulcher, J.: Face recognition using artificial neural network group-based adaptive tolerance trees. IEEE Transactions on Neural Networks 7, 555–568 (1996)
3. Sharath Pankanti, S.P., Anil, K.J.: On the individuality of fingerprints. IEEE Transactions on Pattern Analysis and Machine Intelligence 24, 16 (2002)
4. Strom Bartunek, J.: Minutiae extraction from fingerprint with neural network and minutiae based fingerprint verification. Master's thesis, Blekinge Tekniska Hogskola (2005)
5. Herrera Santana, F.H., Uribe Kaúre, L.: Detección de detalles en huellas dactilares usando redes neuronales. Master's thesis, Pontificia Universidad Javeriana (2005)

6. González Arrieta, A.: Identificación del Arma y la Munición utilizadas en un disparo con técnicas conexionistas. PhD thesis, Universidad de Salamanca; Departamento de Informática y Automática (2000)
7. Shi, Y.Q., You, E., Engler, P.: Fingerprint pattern recognition for medical uses a frequency domain approach. Technical report, New Jersey institute Technology
8. García Ortega, V.H.: Sistema de reconocimiento de huellas dactilares para el control de acceso a recintos. Technical report, Instituto Tecnológico de Chihuahua (2001)
9. Pais Barreto Marques, A.C., Gay Thomé, A.C.: Neural network fingerprint segmentation method. Technical report, Universidade Federal do Rio de Janeiro
10. Vieira Neto, H.: Fingerprint classification with neural networks. IEEE, Los Alamitos (1997)
11. Anbalagan, E., Mohan, E., Jayaraman, B., Puttarnadappa, C., Srinivasarao, M.: Fingerprint authentication using back-propagation algorithm. Medwell International Journal of Soft Computing 3, 6 (2008)
12. García Díaz, P.: Reconocimiento óptico de los puntos característicos de dibujos lofoscópicos. Master's thesis, Universidad de Salamanca (2008)
13. Funahashi, K.I.: On the approximate realization of continuous mappings by neural networks. Neural Networks 2, 183–192 (1989)
14. Williams, R.J., Rumelhart, D.E., Hinton, G.E.: Learning representations by backpropagation errors. Nature 323, 533–536 (1986)