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The Benefit Of Using More Than One Elman Neural Network For Off-Line Signature Recognition System

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***Abstract*- Biometrics is defined as measurements of the unique characteristics of humans and commonly used in the processes of discrimination or electronic identification. And this technique has become the basis for many of the fields because it provides flexibility and a high degree of safety in personal recognition. The signature of human is an important biometric attribute which can be used to authenticate human identity.**

This paper presents a methodology for off-line signature recognition system; this method consists of image preprocessing, features extraction by using Centroid Distance Function,finally build Elman neural network. In general this work displays the compared to the application of Elman neural network in two major cases:

<u>The first case (the traditional way):</u> This is the way of the common methods to train neural networks, and through the construction of neural network and one for all people.

<u>The second case (the proposed method):</u> This method includes several networks by building a neural network for each person (the number of networks is equal to the persons' number).

This system has been tested and gives %89.3 recognition rate. In this system we prove that the using of one neural network for each person is better than the using of one neural network for all persons. This signature recognition system is designed using MATLAB.

Keywords- Signature Recognition; Elman Neural Networks; Centroid Distance Function; Biometrics

I. Introduction

Pattern recognition, comprises a wide diversity of applications and biometrics, is one of its current and emerging application [1]. Biometric recognition is the process of automatic identification of an individual based on its physiological and behavioral characteristics[2],physiological characteristics are related to parts of the body like Face, Facial Thermogram, Fingerprint, DNA, Iris, Ear etc., while behavioral characteristics are related to the behavior of a person like Gait, Signature, Keystroke, Voice etc.[3]

The signature of a person is the way that the person signs her/his name and it's known to be a characteristic of that individual[4],and signature recognition system is verifying the writer's identity by comparing the signature against samples kept in the database [5].

Types of Signature Verification

There are two kinds of signature verification[5]:

Off-line or static signature verification: in off-line signature verification, static characteristics obtained from images of the signature written on a paper using a scanner device or camera.

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On-line or dynamic signature verification: in on-line signature verification, dynamic characteristics obtained from the process of signing, this approach uses signatures captured using pressure sensitive table, the dynamic characteristics include much information like the speed of writing, pressure points, strokes and the shape of signature.

Featuresof Signature Verification

The features that can be extracted from signature can be classified into three main types[6]:

Globalfeatures: like signature height to width ratio, area of signature, Center of gravity etc…, these features are extracted from the whole signature image.

Localfeatures: include critical points, local pixel density, and slant features etc... These features can be extracted from small portion of signature image.

Geometricfeatures: this type of features keeps both their global and local feature properties, and it has the ability to tolerate with rotation variations, distortion and certain degree of translation.

Related Work

Person's recognition (individual identity) by handwritten signature is an acceptable way on a large scale as well as being easy and has a high degree of acceptance by users. Because of the importance of signature to authorize the transfer of funds of millions of people, credit cards and legal documents, Bank checks, etc. all of which require our signatures, it has been extensively studied &implemented; and here are some of these studies:

Daramola Samuel et al. in (2010) presents a new technique to extract features based on signature image splitting ,three robust features are extracted from a static image of signatures using this technique[7].In the same year, Ismail et al. offer a new method for off-line signature identification, the features were extracted using Fourier Descriptor and Chain Codes,Principle Component Analysis has been used in recognition process while a designed multilayer feed forward artificial neural network has been used in verification process [8]. In (2011), Radmehr et al. used Radon Transform, Fractal Dimension (FD) and Support Vector Machine (SVM) in a new offline signature recognition system[9].During (2012), Pansare and Bhatia offer a method of offline signature verification based on neural network, this method uses geometric features extracted from preprocessed signature images.[10]

Recently in (2013),Shukla and Singh used a set of simple shape based geometric features in new prototype for the Offline Verification of signatures, the features are: The Aspect Ratio Of The Signature Sample, The Baseline Slant Angle Of The Signature Sample, The Center of Gravity Of The Signature Sample, The Normalized Area Of The Signature Sample and The Slope Of The Line Joining The Center Of Gravity Of The Vertical Splitting Of The Signature Sample[11].In the same year, an off-line signature recognition and verification system are presented, this system used Invariant Central Moment, Modified Zernike moment for its invariant feature extraction and the back propagation neural network in recognition[12].

II. Centroid Distance Function

Shape Signature is a one-dimensional function which is derived from shape boundary coordinates. It captures the perceptual feature of the shape. There are many types of shape signature like: Complex coordinates, curvature function, centroid distance function, tangent angle (turning angles), triangle-area representation, area function, etc.

The centroid distance function r(n) expressed as the distance of the boundary points from the centroid (gx,gy) (Eq. 1) of a shape

$$r(n) = \sqrt{(x(n) - g_x)^2 + (y(n) - g_y)^2} \quad \ldots(1)$$

Due to the subtraction of centroid, which represents the position of the shape, from boundary coordinates, both complex coordinates and centroid distance representation are invariant to translation[13].

III. Artificial Neural Network

ANN consists of merging two or more of Artificial Neurons ,It represents a mathematical model attempts to simulate the structure and function of biological neural networks and it is characterized by their ability to solve many complex problems by processing information within the artificial neural cells in a Non-Linear, Distributed and Parallel manner.

Artificial Neural Networks Architecture is classified into two basic types depending on the way that the artificial neurons interconnect[14]:

1- Feed-Forward Neural Networks Topology(FNN)
2- Recurrent Neural Networks Topology(RNN)

Elman network is a type of recurrent artificial neural networks. It consists of four layers: The input layer which is used to pass the signals to the network without changing them, The output layer is a linear unit which sums the signals fed to it, The hidden layers can have linear or nonlinear activation functions and the context layers which are used only to memories the previous activations of the hidden layers and can be considered to function as one-step time delays[15].

IV. The Proposed System

This research presents an off-line signature recognition system. our method used type of shape signature called Centroid Distance Function for extract features from the signature images and used Elman Neural Network for recognition. The system consistsof two stages: training stage and testing stage as shown in Fig.(1).

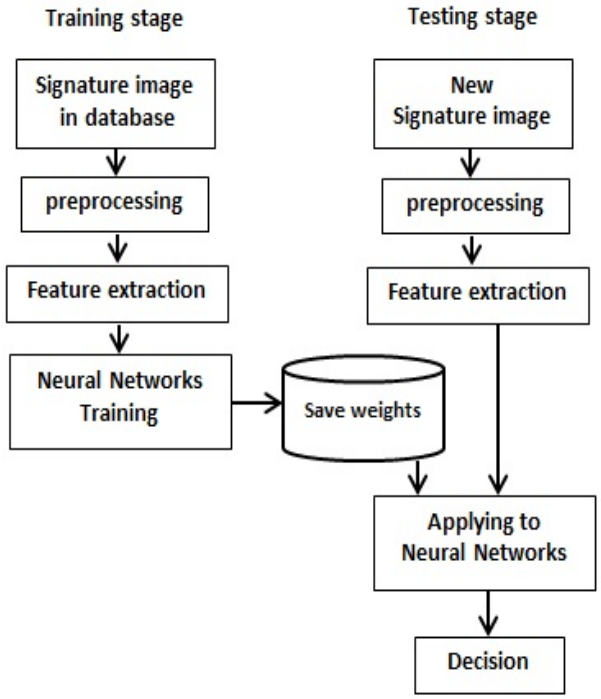

Figure 1. flow diagram of the proposed system

1. The Database

The database is configured by taking the signatures of (15) people, and each person signing of (25) ,the total signatures is (375) , we used the scanner device for the purpose of introducing these signatures into a computer.

2. Preprocessing

The preprocessing consists of four main steps, the output of each step be input to the next step, the steps are:

- **Convert Colored Image to Gray**

After reading the colored image, it converted into gray and thus transformed the image of the three-matrix size (Row ^{x} Column ^{x} 3) to a dual matrix size (Row ^{x} Column), Then send the gray image to the next step. Fig.(2) & Fig.(3) illustrates one signature image before and after converted to gray scale.

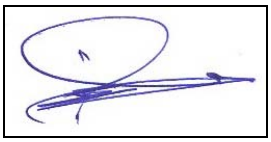

Figure. 2 colored signature image

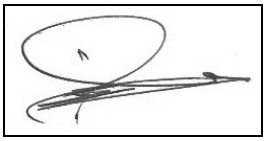

Figure. 3 gray scale signature image

- **Convert the gray image to binary image**

In this step the gray image, which is all the values between (0) and the (255) resulting from the previous step, is converted to a binary image "where all values are either (0) or (1)". Fig.(4)represents the same signature image in Fig.(3) after converting into a binary image.

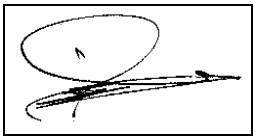

Figure. 4 binary signature image

- **Remove white lines and white columns**

Binary image resulting from the previous step containing white lines and white columns, in this step we delete all the white line and white columns of the image for the purpose of making the image containing the signature only. Figure 3 shows the image before you delete the white line and columns of them, while Fig.(5) shows the image after deleting the white line and columns of them.

Figure. 5 the image after deleting the white line and columns

- **opposite the values of the image**

Opposite all the values in the binary image by converting the value (1) to the value (0) and convert the value (0) to value (1). Through this step the dealing with the white points which have value (1) as part of the body (Signature), the black points which have value (0) as part of the background. Fig.(6) shows the image after the opposite their values.

Figure. 6 the image after the opposite their values

3. Features Extraction

The process of selecting a set of important features from images of signatures is a very important and sensitive process. In our approach we have been using the Centroid Distance Function to extract 355 important features from each signature image.

4. Training of Elman Neural Network

In the training phase, neural networks are trained to perform complex tasks in different areas of applications including pattern recognition, classification, speech recognition, etc.

In this research, instead of using a single neural network for all people who have been taking their signatures, we used one neural network for each person in the database. The Features that have been extracted from the images signatures for the same person are considered as positive examples for the private network to that person (give output (1)), and at the same time is considered as negative examples for the rest of networks (give output (0)). Fig.(7) shows the flow diagram for the training stage of the proposed system.

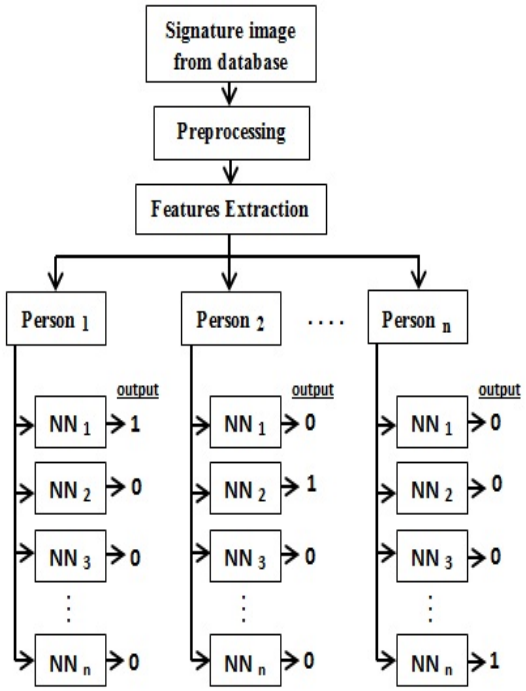

Figure. 7 flow diagram of the training stage

5. simulation of Elman Neural Network for recognition

In the testing phase, new signature image be entered to the system and then preprocessing it and extract the features from it. the features be input to all neural networks that have been configured then outputs are compared with threshold level to decide that the new signature image belongs to any person as shown in Fig.(8)

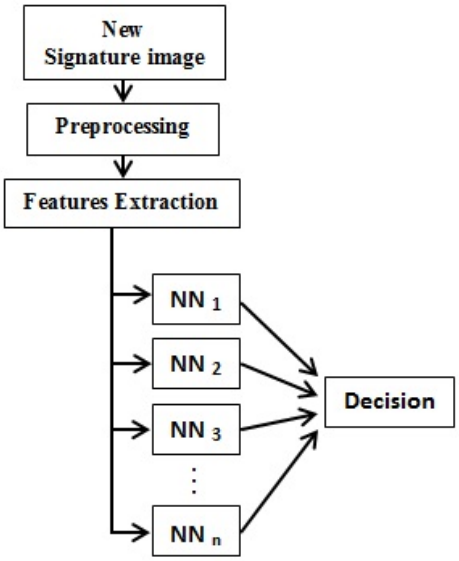

Figure. 8 flow diagram of the testing stage

In this method the numbers of neural networks are used is (15) and it's equal to the number of persons in database, each neural network consists of (5) layers: input layer, output layer and three hidden layers.

The number of neurons in input layer is (355)
The number of neurons in output layer is (3)
The number of neurons in first hidden layer is (150)
The number of neurons in second hidden layer is (100)
The number of neurons in third hidden layer is (30)

6. Algorithm

The algorithm for off-line signature recognition that used neural networks for recognition shown in Table (1)

TABLE 1
Algorithm of the proposed system

Algorithm

1-take the signature image from the database
2-preprocessing the signature image:
- Convert colored image to gray image
- Convert the gray image to binary image
- Remove white lines & white columns
- Opposite the values of the image, (0) to (1) & (1) to (0).

3-extract features using Centroid Distance Function
4-creat features vector
5-training the neural networks using the features vector
6-Repeat steps from 1 to 6 for all signature images in database
7-test the neural networks using new signature image
8-make decision

V. Result and Discussion

The signature recognition system consists of two parts, training and testing. We used (20) signatures for each person to train Elman neural network and used the remaining (5) signature for testing the network.

At the beginning we used one Elman neural network for all persons, the network consists of (5) layers: input layer (has 355 neurons), output layer (has 15 neurons) and three hidden layers (has 150,100 and 30 neurons respectively),the recognition system gives are %100 success rate by recognizing all the signatures that are used to train the network correctly, and gives %81.3 success rate by recognizing the new signatures (the signatures that are not used to train the network) correctly. Table (2) shows the number of times the correct discrimination per person, Table (3) shows discrimination percentages per person.

TABLE 2

P15	P14	P13	P12	P11	P10	P9	P8	P7	P6	P5	P4	p3	p2	p1
3	4	5	4	5	3	4	4	5	4	3	4	5	5	3

TABLE 3

P15	P14	P13	P12	P11	P10	P9	P8	P7	P6	P5	P4	p3	p2	p1
60 %	80 %	100 %	80 %	100 %	60 %	80 %	80 %	100 %	80 %	60 %	80 %	100 %	100 %	60 %

The rate of the total discrimination= %81.3

Then we used (15) Elman neural networks, this way gave also %100 success rate by recognizing all the signatures that are used to train the networks correctly, and give %89.3 success rate by recognizing the new signatures correctly. Table (4) shows the number of times the correct discrimination per person, Table (5) shows discrimination percentages per person.

TABLE 4

P15	P14	P13	P12	P11	P10	P9	P8	P7	P6	P5	P4	p3	p2	p1
4	5	5	5	5	4	4	5	5	5	4	3	5	5	3

TABLE 5

P15	P14	P13	P12	P11	P10	P9	P8	P7	P6	P5	P4	p3	p2	p1
80 %	100 %	100 %	100 %	100 %	80 %	80 %	100 %	100 %	100 %	80 %	60 %	100 %	100 %	60 %

Rate of the total discrimination= %89.3shows Fig.(9) and Fig.(10).

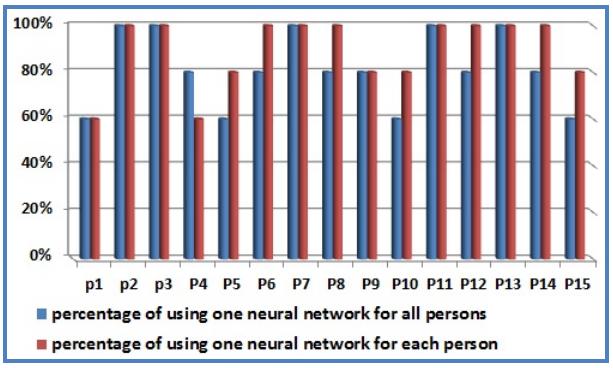

Figure. 9 the difference in percentage for each person

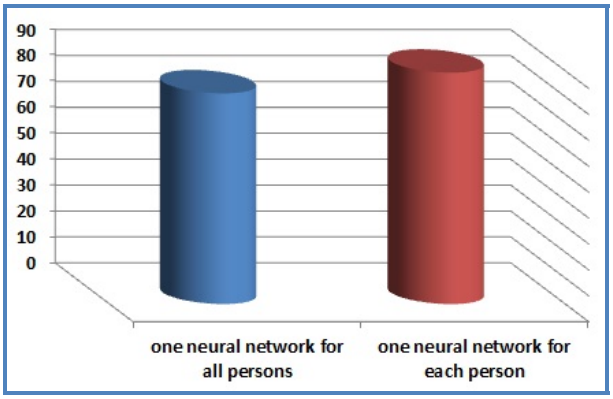

Figure. 10 the difference in percentage of the total discrimination

VI. Conclusion

This paper is presented an off-line signature recognition system based on Elman Neural Network. This system used type of shape signature called Centroid Distance Function to extract features from preprocessing signature image.

This system used number of Elman Neural Networks equal to the number of persons in the database. This method gives %89.3 success rates when recognizing new signature images that are never used to train the networks.

The proposed signature recognition system gives result well than the using of one neural network for all persons in recognition.

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