Recognizing the Isolated Arabic Characters Using Neural Networks

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Abstract

This paper proposes a technique for recognizing isolated Arabic characters using neural networks. This technique consists of three parts: body classifier, complementary classifier, and aggregate classifier. The body classifier is designed to recognize the main body of the unknown character. Hopfield network is used in this part to enhance the unknown character and to get rid of noise and associated complementary. Furthermore, it uses a backpropagation network to recognize the main body of the enhanced unknown character. The complementary classifier recognizes the number of dots or zigzag that are associated with the body of character and their position. The aggregate classifier combines the results of the previous two classifiers and classifies the whole unknown character. As a result of dividing the recognition process into three parts the number of patterns required to be recognized in each part has been reduced as well as speeds up the learning of neural network and increases the recognition rate. The proposed technique has been implemented and shown a reasonable recognition rate.

Keywords: - Neural Networks, Backpropagation Network, Hopfield Network, Character Recognition, Arabic Character Recognition, Pattern Recognition.

1. Introduction

One of the important aspects of automation is Optical Character Recognition (OCR). OCR is the process of translating the graphical document into a textual one. Despite of the large number of researches that have been done in this field, there is no obvious mathematical function that could perform this translation [1, 2]. Considerable attention has been paid to Latin and Chinese character recognition, while Arabic character recognition is still limited in spite of the challenge due to the difficulties of these characters [3, 4, 5, 6]. From the character recognition point of view, the Arabic character recognition is a large problem [6]. This problem arises from the characteristics of Arabic characters and the way these characters are connected and written [7]. Many researches have been done on the Arabic characters [8, 9, 10, 11, 12, 13], some of them have used neural networks [4, 14].

This paper uses two neural networks to recognize the Arabic characters: Hopfield and backpropagation networks. The Hopfield network is a recurrence autoassociative network that works as a memory that can store patterns. It is a single layer network with fully connected neurons. This network returns the stored pattern when the input of the network is the same as the stored one even if it is a noisy version of the stored pattern [15, 16].

In this paper, the Hopfield network is used for eliminating noise and enhancing the body of the unknown character.

The backpropagation network (BPN) is a multilayer neural network trained by backpropagation of errors algorithm. It is simply a gradient descent method to minimize the total squared error of the output computed by the network. The training of a network by backpropagation involves three phases. These phases are feed forward of the input training pattern, backpropagation of the error of this pattern, and updating the weights. After training, the network is applied by using the feed forward phase of the training algorithm [15,16,17].

A multilayer neural network trained by backpropagation is used in this paper to recognize the main body of the unknown character.This paper is organized in four parts. First, the Arabic characters are analyzed and the main problems of these characters are presented. Second, the classification technique and the classifier organization are explained. Third, result and

performance of the proposed technique are compared with a backpropagation network that is trained to recognize the Arabic characters (this backpropagation network will be called *traditional backpropagation network*). Finally, a general conclusion terminates the paper.

2. Problems of Arabic Characters

Arabic writing and Arabic characters have many features that make the Arabic character recognition system different from the recognition systems for other languages such as Latin and Chinese. Arabic words are written from right to left in a cursive script in both handwritten and typewritten [3,4,5,6,18]. Also, Arabic characters have many characteristics that complicate the recognition of such characters. Some of these characteristics are listed below:

1. Arabic alphabet consists of 29 characters. The shape of most of these characters is a function of their positions within the word, where each character can have up to four different forms that increase the number of patterns from 29 to about 60 patterns [3]. Figure (1) shows the Arabic character patterns (each table cell contains one character with different shapes).
2. Most of Arabic characters (17 of 29) have a character complementary that is associated with the body of the character. This complementary may be a dot, two dots, three dots, or zigzag (in Arabic it is called *hamza*). It can be above the character (ف), below (ب), or inside the character (ج) [6].
3. There are many groups of characters that have the same body, but they are distinguished by the number of dots (ـثـ ،ـتـ ،ـنـ), the position of dots (ج خ،), or whether it is a dot or a zigzag (ـئـ ،ـنـ) [6].

ـمـ م	عـ ـعـ ـع ع	سـ س	حـ ح	ء ـئ ئ
ـنـ ن	غـ ـغـ ـغ غ	شـ ش	خـ خ	ا
هـ ـهـ ـه ه	فـ ف	صـ ص	د	بـ ب
و	قـ ق	ضـ ض	ذ	تـ ت ـة ة
يـ ـي ي	كـ ك	ط	ر	ثـ ث
	لـ ل	ظ	ز	جـ ج

Figure (1): Arabic Character Patterns

There are two major problems in Arabic characters that are regarded in this paper. These problems are:

1. *The similarity among each group of different characters*. It is the most important problem in Arabic character recognition system. This problem makes the recognition system unable to absolutely decide what character is under recognition. This problem is due to the character's complementary structures. The dot has no specific shape and can be regarded as a spot of few pixels. The size of this spot determines the number of dots. Whereas the zigzag has a specific shape. Therefore, any considerable noise may influence the recognition system since the noise may be considered as complementary of the character.

Thus, the noise removing process requires a high attention to avoid removing the complementary.

2. *The large number of patterns of Arabic characters*. This problem is due to the multiform of each character depending on the character position within a word. This problem causes a large number of classes that complicate the recognition system.

3.The Proposed Technique

In order to solve the above problems, this paper proposes a recognition technique that is divided into three parts: body classifier, complementary classifier, and aggregate classifier. This organization reduces the large number of patterns into 33 patterns, as well as, minimizing the

similarity among the patterns of different characters. Figure (2) shows the body of characters.

In training process, the prototypes of Arabic characters are manipulated properly to fit the networks training operations. The prototype is pared and centered in a 400x200 matrix of binary values. This matrix translated later to a vector of 800. The unknown pattern is also manipulated in the same way.

و	م	ف	ط	د	ء
ى	ن	ق	عـ	ر	ا
ي	هـ	كـ	ـعـ	سـ	ـا
	ـهـ	ل	ع	س	ب
	ـه	ـلـ	ع	صـ	حـ
	ه	مـ	فـ	ص	ح

Figure (2): Main Body of Arabic Characters

3.1 Body Classifier

This part is designed to classify the main body of the unknown character regardless of the dots or zigzag. In addition, it is responsible of removing the noise and enhancing the main body of the character. This part classifies the main body through two stages. Figure (3) depicts the objective of this classifier.

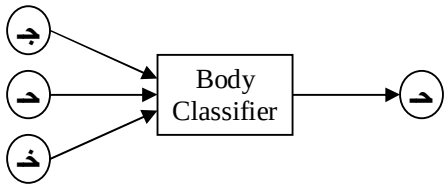

Figure (3): Body Classifier

3.1.1 First Stage

This stage enhances the unknown character and removes the noise and character complementary that is associated with the body of the character. In this stage we use a Hopfield network. To enable this network of removing the noise and enhancing the body of the character, we store the body of Arabic characters within it. The network consists of 800 neurons which is similar to the size of the prototype vectors. The Hopfield retrieves the stored pattern if the submitted pattern is similar to the stored one. Thus, this network will consider the character complementary as a noise and the output of the network will be the stored body that is similar to the body of the unknown character.

3.1.2 Second Stage

This stage receives the output of the Hopfield network (main body) as an input and outputs the class that the unknown pattern belongs to. This stage uses a backpropagation network that is trained to classify the main body of Arabic characters. This network is trained to recognize the body of Arabic characters. It is composed of three layers; input layer, one hidden layer, and the output layer. The input and hidden layers contains 800 neurons whereas the output layer contains 33 neurons. Each neuron of the input layer represent a of the output layer refers to a specific class.

3.2 Complementary Classifier

This part is responsible of recognizing the complementary of the unknown character. It has to determine the number of dots, position, and whether they are dots or zigzag. As it is mentioned above, the

zigzag has a certain shape, whereas the dots have no certain shape. Thus, the dots and their number can be recognized by their size.
In this paper, the complementary is recognized using a mask that is passed along the unknown character. The mask is a matrix of binary values. The proposed system has four masks that take the shape of one dot, two dots, three dots, or the zigzag. Through these masks, we search about the complementary within the unknown character.

3.3 Aggregate Classifier

This part combines the results of the two previous parts and produces the class that the unknown character belongs to. The inputs of this part are the class of the body of the unknown characters and the complementary that is attached to it. The output of this part is class that the unknown character belongs to. Figure (4) shows the function of this part.

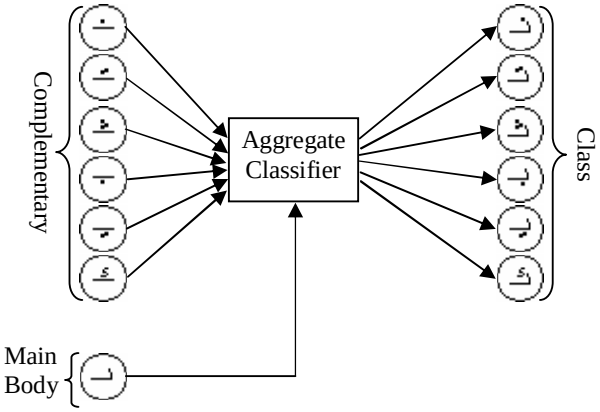

Figure (4): Aggregate Classifier

4 Results

The proposed technique has been implemented and tested along with a traditional backpropagation network. The proposed technique has proved a good behavior on two criteria:

1. Network Training

The number of epochs that are required to train the BPN of the proposed technique is much less than the required epochs to train the traditional backpropagation network as shown in the figure (5).

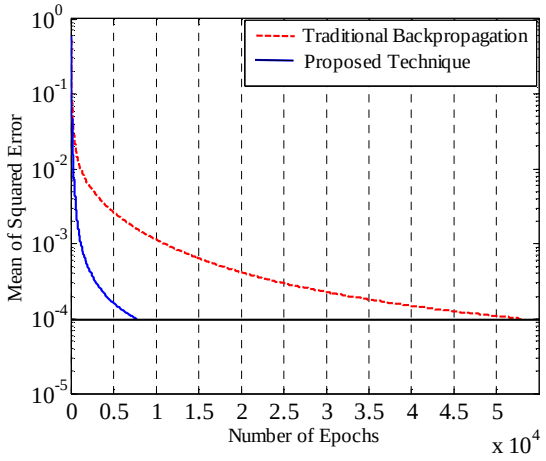

Figure (5): Training Time

2. Recognition Rate

For both of the proposed technique and the traditional backpropagation network, the recognition rate depends on the noise rate in the unknown pattern. But, the traditional backpropagation network has shown a high sensitivity to the noise due to the similarity among groups of Arabic characters. Figure (6) shows the relation between the noise rate and the recognition rate for both proposed system and traditional BPN.

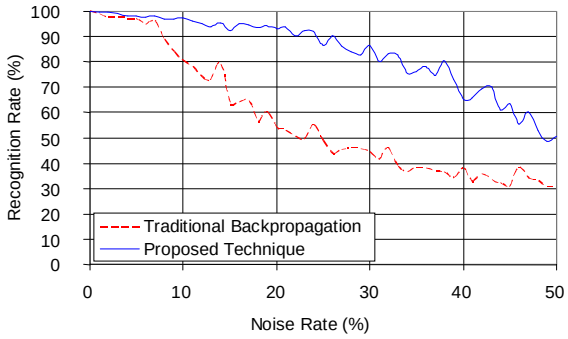

Figure (6): Recognition rate against noise rate

4. Conclusion

It is obvious that the large number of epochs for training the traditional backpropagation network not only because the large number of patterns, but also because of the similarity among groups of different characters. To enable the network of discriminating the similar classes, the network has to take a large number of epochs, as shown in figure (5).

Furthermore, the traditional backpropagation network is very sensitive to the noise as shown in figure (6). This sensitivity is because of the complementary of characters that discriminate the different characters with the same body from each others. Thus, when the backpropagation network considers the noise as a complementary, misrecognition will occur. The organization of the proposed technique and isolation of the complementary classifier overcome the problem of the overlapping between noise and complementary.

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تمييز الحروف العربية المفصولة باستخدام الشبكات العصبية

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الخلاصة

يقترح البحث تقنية لتمييز الحروف العربية المفصولة باستخدام الشبكات العصبية. تتكون التقنية المقترحة من ثلاثة اجزاء: مصنف الحرف, مصنف الملحقات، والمصنف الاجمالي. يقوم مصنف الحرف بتمييز الجسم الرئيسي للحرف غير المعروف قيد التمييز. تم استخدام شبكة هوبفيلد في هذا الجزء لتحسين شكل الحرف والتخلص من التشويش وملحقات الحرف. بالاضافة الى ذلك تم استخدام شبكة الانسياب الخلفي لتمييز الحرف الذي تم تحسينه بشبكة هوبفيلد. اما مصنف الملحقات فيقوم بتمييز عدد النقاط والهمزة ان وجدت مع الحرف وكذلك موقعها بالنسبة للحرف. يستخدم المصنف الاجمالي بتوحيد نتائج المصنفين السابقين ليتم تمييز الحرف بشكل نهائي. ان تقسيم عملية التمييز الى مراحل ساهم في تقليص عدد الانماط المطلوب تمييزها في كل جزء مما ساعد في تسريع عملية تعليم الشبكة العصبية ورفع دقة التمييز.

الكلمات المفتاحية:الشبكات العصبية، شبكة الانسياب الخلفي، شبكة هوبفيلد، تمييز الحروف، تمييز الحروف العربية، تمييز الانماط.