A Serial Combination of Neural Network for Arabic OCR

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Abstract. Today, handwriting recognition is one of the most challenging tasks and exciting areas of search in computer science. Indeed, despite the growing interest in this field, no satisfactory solution is available. For this reason Multiple Classifier Systems (MCS) based on the combination of outputs of a set of different classifiers have been proposed as a method for the developing of high performance classifier system. In this paper we describe a serial combination scheme of an Arabic Optical Character Recognition System. The classification engine is based on Adaptive Resonance Theory and Radial Basic Function, where an RBF network acting as the first classifier is properly combined with a set of ART1 network (one for each group) trained to classify the word image. The experiments applied on the IFN/ENIT database show that the proposed architecture exhibits best performance.

Keywords: Arabic Recognition, Serial combination, Radial Basic Function, Adaptive Resonance Theory.

1 Introduction

In the last few years many academic institutions and industrial companies have been involved in the field of handwriting recognition. The automatic recognition of handwritten word can be extremely useful in many applications where it is necessary to process large volumes of handwritten data, such as recognition of addresses and postcodes on envelopes, interpretation of amounts on bank checks, document analysis, and verification of signatures. Substantial progress has been recently achieved, but the recognition of handwritten word cannot yet approach human performance. The major difficulties descend from the variability of someone's calligraphy over time, the similarity of some characters with each other, and the infinite variety of character shapes and writing styles produced by different writers. Furthermore, the possible low quality of the text image, the unavoidable presence of background noise and various kinds of distortions (such as poorly written, degraded, or overlapping characters) can make the recognition process even more difficult. Therefore, handwriting recognition is still an open and interesting area for research and novel ideas.

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During the 1990's many methods were proposed for combining multiple classifiers for a single recognition task, with these methods, the focus of the field shifted from the competition among specific statistical, syntactic, or structural approaches to the integration of all these as potential contributing components in a combined system. Many combination methods have been proposed, and the applications to practical problems have proven the advantage of ensemble over individual classifiers [1]. A recent survey [13] categorizes the methods into parallel (horizontal) and sequential (vertical, cascaded) ones. Parallel combination [14] is more often adopted for improving the classification accuracy, whereas sequential combination [10] is mainly used for accelerating the classification of large category set.

The proposed classification engine is based on a serial combination of an RBF and an appropriate set of ART1 network. The RBF-based classifier is first used to provide a score for the most likely classes according to feature vector composed of the first 49 Tchebichef moments. Then each ART1 network is applied for each group. Our experimental results done on the IFN/ENIT database provide clear evidence that the proposed combined classifier outperforms either the RBF-based classifier or the ART1-based classifier.

The rest of the paper is organized as follows: Section 2 gives previous work concerning serial combination on Arabic handwriting recognition. Section 3 presents an overview of the proposed Multi Classifier System; section 4 is devoted to computational experiments; and section 5 summarises the main conclusions.

2 Previous Work

The morphology of the Arabic writing presents some characteristics which are the source of their treatments complexity. The Arabic writing is semi cursive script in its printed and handwritten forms [6]. The characters of an Arabic word (or pseudo-word) are horizontally or vertically ligatured which darken the process of segmentation in characters. The forms of letters change according to their positions in the word. Besides, more than half of the Arabic characters include diacritic points in their shape.

In the case of Arabic, the use of the multiple classification schemes is very recent and the number of related publications is not significant. Comparing to the serial combination, there are much interest concerning parallel scheme which is the case in [8], [4], [12], [15] and [16]. We give her related works base on serial combination.

In [4], a strategy for Arabic handwritten word recognition has been proposed. The idea is based on a sequential hierarchical cooperation of three classifiers, all of a Markovian type. The first classifier is based on a global description of the word using sequential visual indices. The second classifier is associated with an analytic approach that models the characters deprived of their diacritic dots. The third classifier is associated to the sub-word. In this hierarchical strategy

of operation, the rates of recognition of the system exceed 89%. This represents an increase of about 8% with respect to the best performing classifier taken individually.

In [4], the recognition of Arabic handwritten words is performed in two steps by Romeo. The first step consists of the classification of the characters in ten groups representing similar characteristics by considering the number of loops and connections with the neighbouring characters. This information is calculated in a preliminary segmentation phase. The second step uses the relevant details between two or more candidate characters with the hierarchical analysis associating the prediction and verification method in order to find the best candidate. The recognition tests include the number of loops, the type of connection with the neighbouring characters (right, left), the number of transitions from the background to the character (horizontal or vertical, and location of a discriminating place), the search of the opening directions (north, south east or west), the size of the characters (width, height), and the number and location of dots.

A handwritten recognition system is proposed in [4] by Touj, in a first step, the character is extracted from its letter image. The character image is then subdivided into equal regions which are used to extract local directional information. The information obtained is converted into a sequence of features that feed a sequential left to right hidden Markov model. The final decision is taken combining the result given by the HMM with the structural information, determined beforehand, relative to the number and the eventual presence of closed loops within the character. The experiments were conducted on 1671 images of handwritten characters written by several writers. 80% of the characters were used in the learning phase, the rest were used for testing purposes. The global recognition rate was of 54% in a first position and reaches 76.3% in the third position.

In [2] Al-Madeed proposed a serial scheme between a rule base classifier and a set of Hidden Markov Models, The handwritten word is normalized so as to be presented in a more reliable manner by the stage of pre-processing, then recognition is carried out to identify the word. First using the global feature engine to reduce the original lexicon by giving 8 word groups. The HMM recogniser is then applied to that reduced lexicon, then the data likelihoods for each frame of data in the representation are estimated using a vector quantization method. The system has been applied to a database of handwritten words produced by 100 writers. Samples of about 4700 Arabic words for the lexicon used in cheque filling were gathered and stored in separate files respect, the recognition rate was about 60%.

Al Ohali [3] opted for neural/HMM serial combination for Arabic handwriting recognition, Khonen neural network is used as a first classifier for reducing the input sub-word giving 20 groups, each one contained 24 sub-word. Tested on a database of 67 sub-word class, the neural classifier gave a reused rate of 99,04%. Combined with the Markovian classifier, the recognition rate augment by 3,68%, the final recognition rate was 73,53%.

3 Combining Neural Networks

In serial combination, the classifiers are arranged in a list. For each pattern to be recognized, the first classifier is used to decide if a possible refinement of the decision is required by one or more subsequent classifiers. Among different combination architectures, the most common are the conditional and the hierarchical ones. In the conditional combination architecture, the second classifier is applied only when the first one rejects the incoming pattern. In the hierarchical combination architecture the first classifier (sometimes called the reducer) is used to limit the lexicon for the subsequent recognition stages. The latter approach has been mainly introduced for the recognition of handwritten words, where a large vocabulary is required.

The classification scheme that we propose is based on a particular serial hierarchical combination of an RBF with a set of ART1 networks.

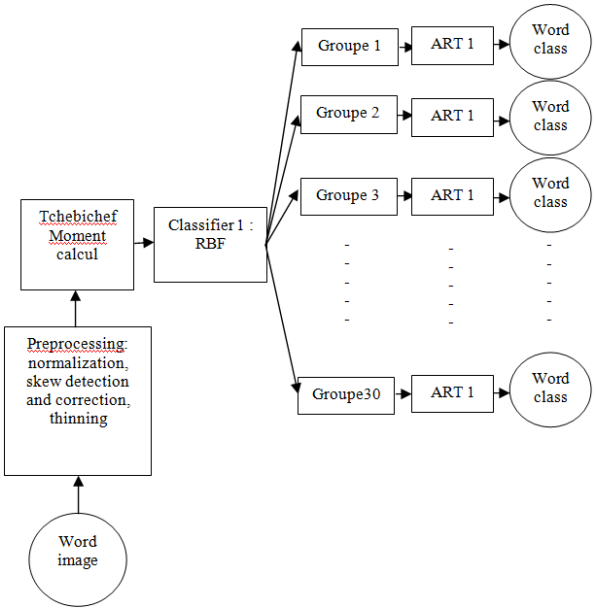

Fig. 1. Multi-Classifier system architecture

The handwritten word is normalized, aligned and thinned for extracting the 49 first Tchebichef moments; the detail of preprocessing operations and Tchebichef calculating moments is given in [5]. RBF network is used to reduce the original lexicon of 180 word images. By obtaining 30 groups, each one having 60 word images, so ART1 network works only on a group of 60 word images.

4 Experimental Results

We have used IFN/ENIT database [18] which was produced by the Institute for Communications Technology at the Technical University of Braunschweig (IFN) and the Ecole Nationale d'Ingnieurs de Tunis. The total number of binary images of handwritten Tunisian town/village names is 26459. Those names were written by 411 writers, and they were labelled according to 946 name classes.

Table 1. Reported recognition rate for each group

Groups number	Recognition rate (%)
Group 1	75.45
Group 2	76
Group 3	76.52
Group 4	78.89
Group 5	75.25
Group 6	74.35
Group 7	77.87
Group 8	79.01
Group 9	78
Group 10	76.89
Group 11	80.50
Group 12	76.75
Group 13	75.75
Group 14	78.90
Group 15	74.82
Group 16	73.32
Group 17	77
Group 18	74.12
Group 19	75.7
Group 20	73.45
Group 21	76.87
Group 22	74.75
Group 23	75.58
Group 24	79.30
Group 25	76.57
Group 26	78.30
Group 27	78.25
Group 28	76
Group 29	77.75
Group 30	79.42
Average recognition rate	**76.69**

Table 1 show the recognition rate achieved in each group where the final recognition rate is 76.69%. Comparison of the results obtained in this research with other research is difficult because of differences in experimental details concerning the used database.

5 Conclusion

A complete scheme for unconstrained Arabic handwritten word recognition based on neural networks is presented. The overall engine of this combination of Radial basic function with Adaptive resonance Theory is a system able to classify Arabic handwritten words. The system first applies some preprocessing operation; normalization, skew detection and correction and thinning, then a feature extraction phase is done with Tchebichef moments. Next, an RBF network is used as a first recognition engine producing 30 groups; each one contains 60 word images. Finally, for each group, the ART1 network is used for trial classification. The achieved recognition rate is 76.69%.

The obtained results are promising according to the novelty of the idea in spite of the problems finding in the data base concerning the bad writing. The post processing step was not approached in our work; it will be discussed in our future modifications to the system.

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