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A Neural Network Based Multiple Expert System Model for Conflict Resolution

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Abstract

The paper describes a Neural Network and Multiple Expert System Model for Conflict Resolution of Unconstrained Handwritten Numerals. The basic recognizer is the Neural Network. The Neural Network classifier is a combination of Modified Self-Organizing Map (MSOM) and Learning Vector Quantization (LVQ). It will solve most of the cases, but will fail in certain confusing cases. The Multiple Expert System, the second recognizer, resolves the confusions generated by the Neural Network. This Expert System increases the confidence level of each decision made by the neural network recognition system of the first stage and corrects the possible substitution, thus resulting in a most reliable system. The results obtained from this architecture are compared with comments collected from an experiment conducted with a group of human experts specialized in unconstrained handwritten character recognition. The developed system is giving the same confusing pair as that given by the group of human experts and it also resolves the confusion.

Keywords : Feature Extraction, Modified Self-Organizing Map, Learning Vecotr Quantization, Human Experts, Conflict Resolution.

Introduction

We have proposed a generalized neural network based expert system model for character recognition, especially in case of confusions [1, 2]. Several approaches for combining decisions from multiple recognizers are possible. However, optimality is difficult to achieve due to practical limitations such as finite data, high dimensionality and unknown density function. Neural Networks have been shown to approximate Bayesian decisions [3]. Also, combined unsupervised-supervised learning of optimal description of feature space by neural networks is a new and promising approach for robust handwritten character recognition [4, 5]. Expert system is a validation module which makes a more informed decision about the classification than the neural network. The confidence levels obtained from the neural network are stored in the knowledge base using the frame model of knowledge representation [6].

In this paper a neural network based multiple expert system model has been proposed for conflict resolution of unconstrained handwritten characters and it completely resolves the confusion between the conflicting characters. The basic recognizer is the neural network. This neural network classifier is a combination of Kohonen Modified Self-Organizing Map (MSOM) and Learning Vector Quantization (LVQ). The expert system, the second recognizer, resolves the confusions generated by the neural network by computing the average experts' opinion. The pattern with a maximum average opinion (maximum confidence level) is recognized. The goal of this experiment is to compare the per-

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formance of human experts and to show that it is possible to reduce the substitution rate while maintaining a reasonably high recognition rate of totally unconstrained handwritten PIN or ZIP code numerals, and finally aiming at outperforming human experts.

Modified Feature Extraction

The conventional feature extractor converts handwritten characters into a highly compressed form[7]. This method is suitable only for the uppercase letters of the English alphabet. However, the feature extraction of all the unconstrained handwritten characters which are written in different styles is not possible. For example, the horizontal features extracted for the samples using this method are not recognized properly. This disadvantage is taken care of in the modified feature extractor by making the vertical regions unsymmetrical.

In the proposed method by using the modified encoding method thirteen features of each pattern are extracted. These features are used during the training process of the neural network. The training process is carried out using Kohonen's Modified Self- Organizing Map and Learning Vector Quantization method.

Kohonen Modified Self-Organizing Map

In the conventional Self-Organizing Map (SOM) the misclassification is more [8, 9, 10] because the minimum distance formula is applied for both the standard as well as distorted sets of samples. This disadvantage is taken care of in the Modified Self-Organizing Map (MSOM) by applying the minimum distance formula only for the standard set of samples. Also in this modified method we update the weights in the neighbourhood by repeating on the same size twice. This improves the classification. The Learning Vector Quantization method [8, 10] is further used for better classification.

Learning Vector Quantization

Kohonen has suggested that if the nodes of the Self- Organizing Map are used for Pattern Recognition, their classification accuracy can be multiplied if the nodes are fine tuned using the supervised learning principle [10]. Fine tuning is achieved by selecting the training vectors x with known classification and presenting them to the network to examine the cases of misclassification. The best match comparision is performed at each node and the winner node is noted. By means of the LVQ algorithm patterns are self-organized into a fine tuned feature map.

Expert System

We have developed a two-tier architecture character recognition system. The basic recognizer is the neural network. It recognizes most of the cases correctly but will fail in certain confusing cases and expert system is the second recognizer, which resolves the confusion generated by neural network.

table The operations carried out by the expert system are as follows: (i) Mapping of the conflicting character onto the classifier and collecting the confidence levels. (ii) Searching for the maximum confidence level. (iii) Searching for the next maximum confidence level. (iv) Comparing the maximum and the next maximum confidence levels for checking the presence of confusion. (v) In case of a confusion define the clusters which contain one or more interrelated classes. (vi) Processing of the current confidence levels of a set of samples into their equivalent knowledge representation form. (vii) Growth of the knowledge base on the basis of current history. (viii) Finding the cluster which contains maximum confidence value class. (ix) Collecting the opinions of experts about the classes of a cluster. (x) Finally, computing the average experts' opinion for each class. The class with maximum experts' opinion contains the recognized character.

Results

The data used in our work is collected from the dead letter envelopes of U.S. Postal Services at different locations in the U.S. We have choosen 400 samples (from various research papers) which are the most difficult or confusing specimens in a database of approximately 17,000 digits.

The average opinion of a group of five human experts who particitpated in a experiment, in relation to three confusing samples is shown in fig. 1. The average opinion for the confusing pattern of fig.2, as given by our system is shown in table 1. It is observed

Table 1: Performance of Neural Network Based Multiple Expert System Model given by 12 Experts (Average opinion)

SL.No	Numerals	Average opinion (%)
1	Zero	20.22
2	One	0.00
3	two	28.95
4	Three	0.00
5	Four	0.00
6	Five	10.46
7	Six	16.72
8	Seven	23.83
9	Eight	0.00
10	Nine	0.00

that the developed system is giving the same confusing pair as that given by the human experts and is also able to resolve the confusion.

Conclusion

In this paper a neural network using the Modified Kohonen Self-Organizng Map and Learning Vector Quantization techniques, and expert system model for conflict resolution on ambiguous patterns has been accomplished. The results lead to infer some interesting properties of the human behaviour in the classification process. The developed system resolves the confusion completely. The system is robust and accurate in the recognition of unconstrained handwritten characters. This system has been very useful in resolving conflicts of unconstrained handwritten characters in PIN or ZIP Codes of mailing addresses. In particular this work should be very useful in overcoming the dead letter problem of postal department.

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0 - 8 [44 % - 44 %]

2 - 7 [45 % - 45 %]

4 - 9 [60 % - 60 %]

Fig. 1. Confusion due to substitution error Given by a Group of Human Experts.

2 - 7 [28.95 % - 23.83 %]

Fig. 2. Confusing Sample Confidence Levels (%) Given by the System.