Application of Growing Hierarchical Self-Organizing Map in Handwritten Digit Recognition

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Abstract: This paper discusses the application of a GH-SOM architecture to the problem of Handwritten Digit Recognition. The results proved to be better than the ones obtained from standard SOM networks.

1. Introduction

The recognition of handwritten digits is an important area in automated document analysis of postal addresses, bank checks, census forms, among other applications. The MLP-BP neural networks are being widely applied in this area. However, for large-scale real applications, this paradigm requires a long training time [1]. In this context, some authors proposed efficient methods based on *Self-Organizing Maps* (SOM). *Laterally Interconected SOM* was applied to learn the digits' internal representations that are easy to recognize with a perceptron network [2]. Wu applied SOM followed by LVQ to recognize handwritten digits [3]. Zhang used ten *Adaptative-Subspace SOM* modules to capture different features in the ten classes of digits [4]. The novelty of this paper is the application of a variation of SOM (GH-SOM) to the problem of handwritten digit recognition and the comparison of its results with the ones obtained by a stardard SOM.

2. Growing Hierarchical SOM

In a conventional SOM, the number of neurons needed by the learning process increases exponentially with the size of the input vector. The full-search algorithm has a complexity $O(n)$, where n is the number of neurons. A search algorithm with $O(\log n)$ complexity can be obtained if the neurons are arranged in a tree. In order to address the limitations of the conventional SOM, models of hierarchical SOMs (H-SOM) were proposed [5,6]. H-SOM is a tree-structured neural network composed of independent SOMs that is capable of representing hierarchical relations between the input data. In this model, however, the sizes of the various SOMs that form the hierarchy have to be defined prior to training. In the *Growing Hierarchical SOM* (GH-SOM) the size of these SOMs as well as the depth of the hierarchy is determined during via unsupervised training process [7].

3. Experiments, results and conclusions

The handwritten digits in our experiments were extracted from the MNIST database. We used 2000 digits for training and 3000 for testing. The original 28x28 grey level images were resized to 16x16. Some examples of the digit set are presented in Figure 1.

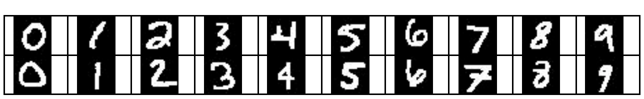

Figure 1: Some examples of the MNIST datahase

In the first experiment, a 4 layer GH-SOM, consisting of 206 SOMs, was generated in the training phase. In the second experiment, a 35x33 SOM, equivalent in size to the GH-SOM, was trained. The training of the SOM was stopped when it reached a quantization error approximately equal to that of GH-SOM. Overall, the classification rates of GH-SOM were slightly better than the SOM ones. However, while the GH-SOM takes approximately 0,3s to recognize a pattern, using matlab in a standard 1GHz computer, the conventional SOM takes approximately 30s. That is, the GH-SOM is 100 times faster than the SOM. In conclusion, GH-SOM was better than standard SOM in the sense that its architecture is determined automatically, presented better recognition rates in the digit recognition problem and is much faster in recognition mode.

CLASS	GHSOM	SOM
0	96,63%	94,94%
1	96,24%	98,55%
2	87,18%	88,14%
3	77,06%	78,14%
4	67,62%	64,06%
5	79,24%	75,47%
6	89,65%	94,48%
7	78,55%	82,18%
8	79,73%	72,76%
9	83,44%	79,45%
TOTAL	**83,9%**	**83,23%**

Table 1: Classification rates.

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