Improved Method of Handwritten Digit Recognition

Ernst Kussul, Tatyana Baidyk
UNAM, Centro de Instrumentos,
Cd.Universitaria A.P.70-186 C.P.04510 Mexico, D.F.

ekussul@servidor.unam.mx
tbaidyk@aleph.cinstrum.unam.mx

Abstract

MNIST database serves for comparison of different methods of handwritten digit recognition. There are many data related to different classifier recognition rates among which our neural classifier had the second place [1] (recognition rate 99.21%). At present we develop improvements of neural network structure and algorithms of handwritten digit recognition. Improved classifier has recognition rate 99.37%. This result is the best from the known ones. In this paper we briefly describe the general structure of our classifier and the latest improvements.

1 Introduction

There are many applications, which need to recognize handwritten digits. For example, bank checks, custom declaration automatic reading etc.

Various methods were proposed to solve this problem [2], [3]. For estimation of the method effectiveness the most important parameter is recognition rate. This parameter show, which proportion of samples in test database is recognized correctly.

The MNIST database contains 60,000 handwritten digits in the training set and 10,000 handwritten digits in the test set. Different classifiers proved on this database by LeCun [2] had shown recognition rate from 88% till 99.3% (Table 1).

We have developed new neural classifier LIRA (LImited Receptive Area classifier) based on Rosenblatt's perceptron principles. To adapt Rosenblatt's perceptron for handwritten digit recognition problem we made some changes in perceptron structure, training and recognition algorithms.

Rosenblatt's perceptron contains three layers of neurons. The first layer *S* corresponds to retina. In technical terms it corresponds to input image. The second layer *A* called the associative layer corresponds to feature extraction subsystem. The third layer *R* corresponds to output of all the system. Each neuron of this layer corresponds to one of the output classes. In handwritten digit recognition task this layer contains 10 neurons corresponding to digits 0, ..., 9. Connections between the layers *S* and *A* are established using a random procedure and cannot be changed by perceptron training. They have the weights 0 or 1.

Table 1: Recognition rate of different classifiers

METHODS	% OF ERROR NUMBER
Linear classifier	12.0
Linear classifier (nearest neighbor-NN)	8.4
Pairwise linear classifier	7.6
K-NN, Euclidean	5.0
2-layer NN, 300 hidden units (HU) (28x28-300-10)	4.7
2-layer NN, 1000 HU (28x28-1000-10)	4.5
2-layer NN, 1000 HU, [distortions] (28x28-1000-10)	3.8
2-layer NN, 300 HU, [distortions] (28x28-300-10)	3.6
1000 RBF (Radial Basis Function) + linear classifier	3.6
40 PCA (Principal Component Analysis) + quadratic classifier	3.3
3-layer NN, 300+100 HU (28x28-300-100-10)	3.05
3-layer NN, 500+150 HU (28x28-500-150-10)	2.95
3-layer NN, 300+100 HU, [distortions] (28x28-300-100-10)	2.5
3-layer NN, 500+150 HU, [distortions] (28x28-500-150-10)	2.45
K-NN Euclidean, deslant	2.4
LeNet-1 [16x16]	1.7
2-layer NN, 300 HU, [deslant] (20x20-300-10)	1.6
K-NN, Tangent Distance, [16x16]	1.1
SVM (Support Vector Machine) poly 4	1.1
LeNet-4	1.1
LeNet-4 / K-NN	1.1
LeNet-4 / Local	1.1
Reduced Set SVM poly 5	1.0
LeNet-5	0.95
Virtual SVM poly 9 [distortions]	0.8
LeNet-5 [distortions]	0.8
Boosted LeNet-4 [distortions]	0.7
Proposed classifier LIRA	**0.63**