Comparison of Multiclass Kernel Support Vector Machines and Neural Networks for Image Classification

Kernel-based Machine Learning and Multivariate Modeling - project

Lucas Robin and Matthias Hertel

December 30, 2016

Contents

1 Introduction

1.1 Task

In this project we compare Kernel Support Vector Machines (KSVMs) and state of the art techniques like Convolutional Neural Networks (CNNs) for image classification.
Since image classification is a multi-class problem, we implement our own strategies of how to use KSVMs in order to decide which class will be assigned to a given image, and we compare our strategies to the strategies which are implemented in the R-library *kernlab*.
Both CNNs and KSVMs have a lot of parameters, so a main part of our work was to search for parameter settings that lead to good classification results.

1.2 Datasets

We have three different datasets with varying kinds of images, image sizes and dataset sizes.

1.2.1 ZIP

The ZIP dataset was provided in the second part of the course for some homeworks. It contains 16x16-pixel grayscale images of handdrawn digits from 0 to 9. The dataset is rather small with a training set of 7291 and a test set of 2007 images. See Figure 1 for example images.

1.2.2 MNIST

The MNIST dataset is frequently used in the image classification literature and can be considered to be a standard dataset. We downloaded the dataset from [Yann LeCun's homepage]. It contains 28x28-pixel grayscale images of handdrawn digits from 0 to 9. The dataset is bigger than the ZIP dataset and comes with a training set of 60000 and a test set of 10000 images. See Figure 2 for example images.

1.2.3 CIFAR-10

The CIFAR-10 dataset contains 32x32-pixel RGB-coloured images of the following ten classes (see Figure 3 for example images):

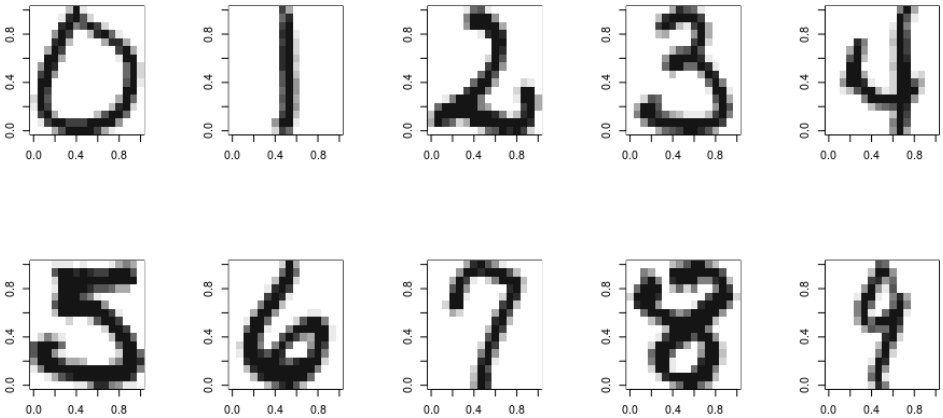


Figure 1: Example images of the 10 classes of the ZIP dataset.

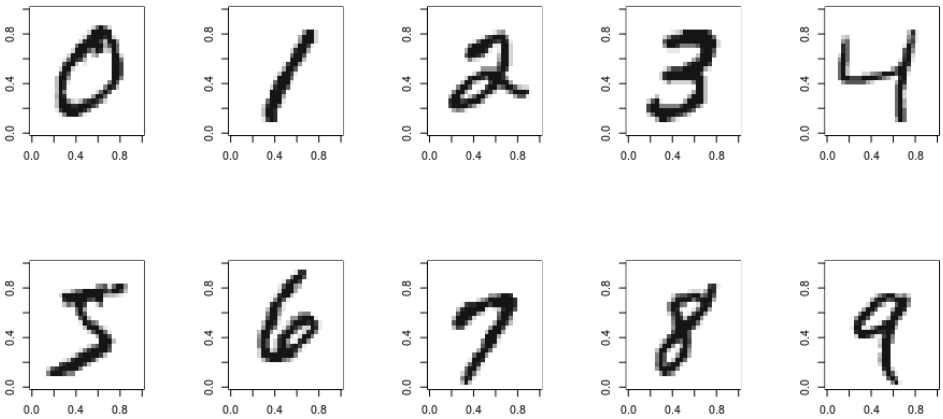


Figure 2: Example images of the 10 classes of the MNIST dataset.

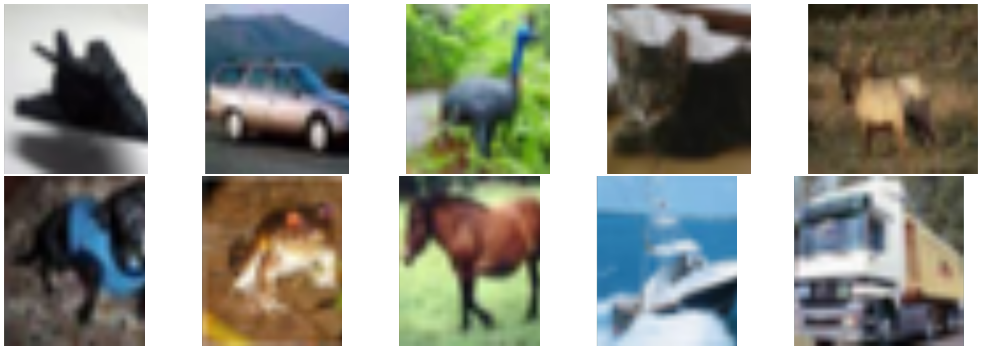


Figure 3: Example images for the 10 classes of the CIFAR-10 dataset.

1. airplane
2. automobile
3. bird
4. cat
5. deer
6. dog
7. frog
8. horse
9. ship
10. truck

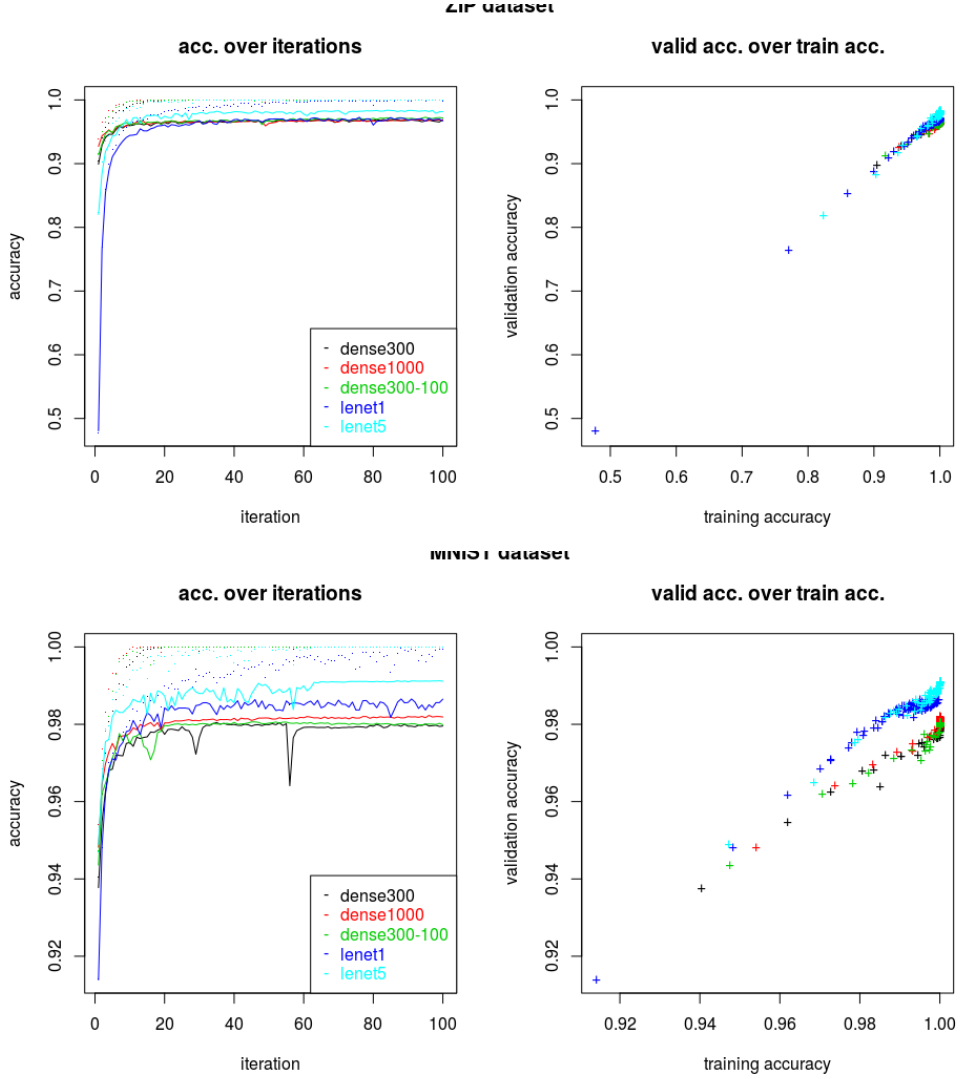
The dataset is divided into a training set of 50000 and a test set of 10000 images. All the data can be found on [Alex Krizhevsky's homepage].

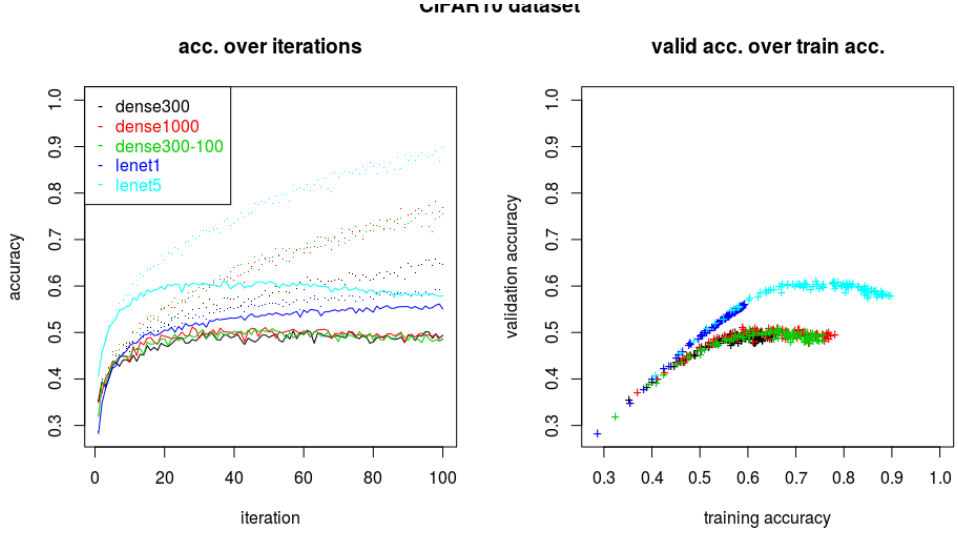
2 Neural Networks

2.1 Architectures

All the network architectures are inspired by [LeCun et al., 1998].

2.2 Results


ZIP dataset
acc. over iterations
valid acc. over train acc.
accuracy
validation accuracy
iteration
training accuracy
dense300
dense1000
dense300-100
lenet1
lenet5
MNIST dataset
acc. over iterations
valid acc. over train acc.
accuracy
validation accuracy
iteration
training accuracy
dense300
dense1000
dense300-100
lenet1
lenet5



2.3 State of the art

3 Multiclass Kernel SVMs

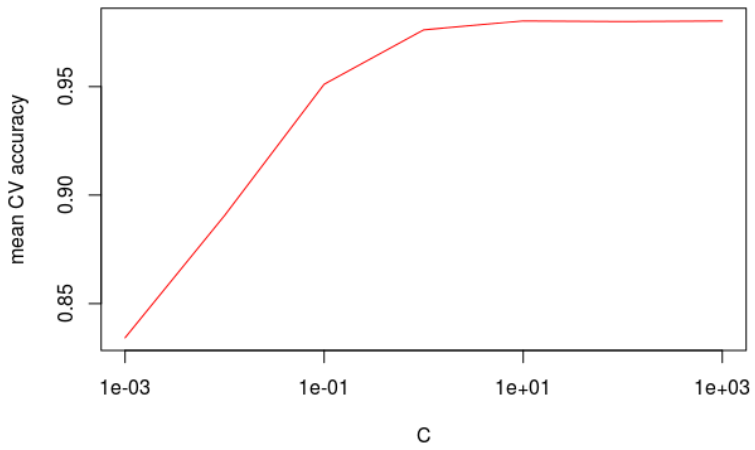
3.1 Multiclass SVM strategies

3.1.1 spoc-svc

This method for multi-class classification is based on a new definition of the margin. This generalized notion of margin gives to the method the ability to learn a multi-class classifier simply by solving a constrained optimization problem with a quadratic objective function.
See [Crammer and Singer, 2001] for more details.

3.1.2 kbb-svc

In this case, we extend the binary SVM optimisation problem by adding new decision variables and new constraints. This method implies that the size of the optimisation problem is proportional to the number categories, which can be a problem.
See [Weston and Watkins] for more details.



References

[LeCun et al., 1998] Y. LeCun, L. Bottou, Y. Bengio, P. Haffner, *Gradient-Based Learning Applied to Document Recognition*, Proc. of the IEEE, November 1998.

[Alex Krizhevsky's homepage] https://www.cs.toronto.edu/~kriz/cifar.html

[Yann LeCun's homepage] http://yann.lecun.com/exdb/mnist/

[Crammer and Singer, 2001] K.Crammer, Y. Singer, *On the Algorithmic Implementation of Multiclass Kernel-based Vector Machines*, pp. 265-292, Journal of Machine Learning Research 2, 2001.

[Weston and Watkins] J. Weston, C.Watkins, *Support Vector Machines for Multi-Class Pattern Recognition*