Convolutional Neural Network (CNN)

CNN are neural network often used for analysis of images. It starts with one or more convolutional layers which are afterwards flattened and used as the input for a fully connected neuronal layer.

Implementation:

The program is based on the Pytorch library. It is build as follows:

- Input is a 28x28 pixel image
- Convolution layer 1: input channel = 1 (grayscale); output channel = 24; kernel size = 5; stride = 3 and a LeakyReLU activation
- Fully connected layer: Linear with input size = 1536; output size = 10 ()

Optimizer: SGD (Stochastic gradient descent)

Output processing with Logarithmic-softmax function

Loss function: NLLLoss (negative log likelihood loss) (needs as input log probability of classes)

Parameter optimization:

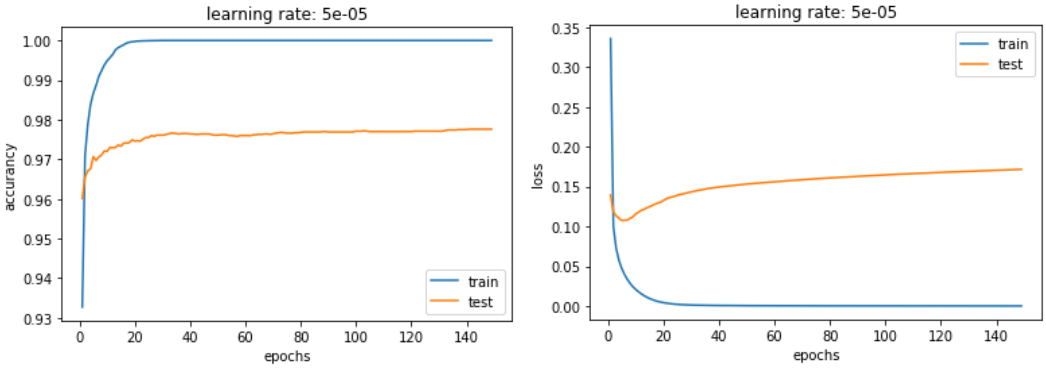
- First learning rate is optimized by testing a range of different learning rates (0.1, 0.01, 0.001, 0.0005, 0.0001, 0.00005, 0.00001)

Best learning rate *= 0.00005*

- Afterwards the epoch size was optimized. For this 148 epochs were run

Best epoch size *= 141*

Results:



The optimal epoch size was found by 141. If we look at the plotted accuracy we see that there seems to be a first optimum at 33 epochs. 33epochs seems more reasonable than 141, because 141 epochs take too long to calculate. Furthermore the accuracy drop around 60 epochs seems to suggest that there is already some over fitting there.

Interestingly the lowest Loss is already reached after 5 epochs with a loss of 0.10742966911707026. This seems to suggest that over fitting actually already begins after 5 epochs.

The optima from accuracy and loss interestingly differ allot. This can be explained because the accuracy is based on a guessed category whereas the loss is calculated from the log_softmax output which gives all categories a probability higher than 0.

With the optimal parameter the Network was tested. For this 10 networks were initialized and calculated. Because minimal loss is for 5 epochs and maximal accuracy is for 33 epochs both were tested.

For 5 epochs: 97.10% accuracy; 0.11347 Loss
For 33 epochs: 97.79% accuracy; 0.136657 Loss
Even after multiple random initialisations 33 epochs give a higher Test set accuracy:

Best Results = 97.79% accuracy; 0.136657 Loss