Prof. Dr. Volker Roth
volker.roth@unibas.ch

Vitali Nesterov
vitali.nesterov@unibas.ch

Department of Mathematics and Computer Science
Spiegelgasse 1
4051 Basel

Exercise 7

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7.1: Classification of handwritten digits

Recall the convolutional neural network setup. In this exercise, a model predicts class labels for a set of hand written digits. Note that in a binary classification setting a logistic regression suffice. In our case, however, the amount of classes is 10, being a multinomial logistic regression, a.k.a., a softmax regression problem. The output of the model is a probability distribution consisting of K bounded reals.

Neural network architecture

- A convolutional layer with a single input channel, 32 output channels, a kernel size of $(3, 3)$, a stride of one, and a ReLU activation. self.cnn_layer1
- A 2-d max-pooling layer with a kernel size of $(2, 2)$. self.cnn_layer2
- A convolutional layer with 32 input channels, 64 output channels, a kernel size of $(3, 3)$, a stride of one, and a ReLU activation. self.cnn_layer3
- A 2-d max-pooling layer with a kernel size of $(2, 2)$. self.cnn_layer4
- A dropout layer with a dropout-ratio of 20 percent. self.cnn_layer5
- A fully connected layer with (?) inputs and 128 outputs including a ReLU activation.
- A dropout layer with a dropout-ratio of 20 percent.
- An output layer with 128 inputs and 10 outputs including a log-softmax activation.

Exercise

Write a Python program, include PyTorch package for implementation of a neural network model to solve the image classification problem. Be aware that the model training process is time-consuming.

- Implement the neural network architecture as stated above.
- Compute the input dimension of the first fully connected layer by hand.
- Train the model and validate it with respect to the prediction accuracy. Save the model after each training epoch.

Figure 1: A plot of wrongly classified handwritten digits. Each row depicts false classifications for a particular class. The ordering of the rows is with respect to the class label and is in the ascending order.

- After the training, evaluate one of the stored models on the test data. Plot 10 false classifications for each class (see Figure 1) and print wrongly assigned class names.
- What is the purpose of a softmax activation and why is a log-softmax function more convenient?