TUM EI 70360: Machine Learning and Optimization
Fall 2023
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Problem Set 11
Issued: Tuesday, Jan. 9, 2024
Due: Thursday, Jan. 18, 2024

Problem 1 (Computational cost of a convolutional layer)**.** Consider a convolutional layer mapping a volume of dimensions $c \times w \times h$ (i.e., c channels, and images of width w and height h) to another volume of the same size. The kernel has size $k \times k$. What is the computational cost of the convolutional layer (in big-O notation)?

Problem 2 (Convolutional neural networks)**.** In this problem we will explore image classification with convolutional neural networks. We consider the same problem setup as in the previous homework, i.e., 3000/1000 train/test images from the classes cat, dog, ship from the CIFAR10 dataset.

1. Inheriting from `nn.Module`, implement a convolutional neural network consisting of two `Conv2d` layers with 6 and 16 output channels respectively and a kernel size of 5. Each convolutional layer is followed by a ReLU activation and a `MaxPool2d(2,2)` operation. After the convolutional layers apply two linear layers with ReLU activations and output dimensions of 120 and 84 respectively. Remember to flatten the tensors that were processed by the convolutional layers before handing them to the linear layers. Finally, apply a last linear layer without an activation function and output dimensions equal to the number of classes. Train the CNN with the same training setup as in the previous homework and compare the performance to what you obtained with a fully connected neural network in the previous homework.

2. Shuffle the pixels of each of the images (training and test set) with the same random permutation, and train the CNN again. How does the classification performance change? Explain why.

3. Train and test the fully connected neural network from the previous homework on the shuffled dataset. How does the classification performance change compared to the performance from the previous homework? Explain why.