Neural Nets: Problem Set 3

Due Friday Feb. 27 on Blackboard.

February 23, 2015

Download `LeNet.zip`, which contains MATLAB code for applying a convolutional network to the MIST dataset. Also download `mnist.zip`, which contains the full MNIST training and test sets. Please submit your solutions in one concise .pdf file. Do not submit code.

1. The architecture has two layers of convolution and max pooling, followed by two fully connected layers. This is a simplified version of LeNet-5, described in the paper by Yann LeCun et al. (included in the zip archive). List concisely the ways in which the code is different from the implementation in the paper.

2. Use MATLAB's built-in profiler to identify the five most time-consuming statements in the code.

3. Add code for biases. Note down the changes in your code.

4. Add code for the option of average pooling, note down the changes in your code. Your code should train the weight and bias of each average pooling operation. Describe concisely in words and/or equations what the code does.

5. Train using the 60,000 examples in the training set. Write a script that computes training and test error of a trained network. What values do you get?

6. Try to optimize generalization performance by experimenting with variations in:

   (a) number of feature maps or neurons in a layer
   (b) filter sizes in a convolution layer
   (c) number of convolution layers
   (d) number of fully connected layers
   (e) max vs. average pooling
   (f) how you initialize the synaptic weights and biases
   (g) the learning rate parameter η
   (h) training set distortions
   (i) whatever else you like (You can find ideas in the included papers.)

   What is the best test error that you can obtain? Report the properties of the best network that you found. Compare with the state-of-the-art as reported in two more recent papers by Ciresan et al., included in zip archive. These papers demonstrated that GPU implementations of multilayer perceptrons and convolutional nets could attain superior performance.