

DATA 221

Homework 4 (rev 2)

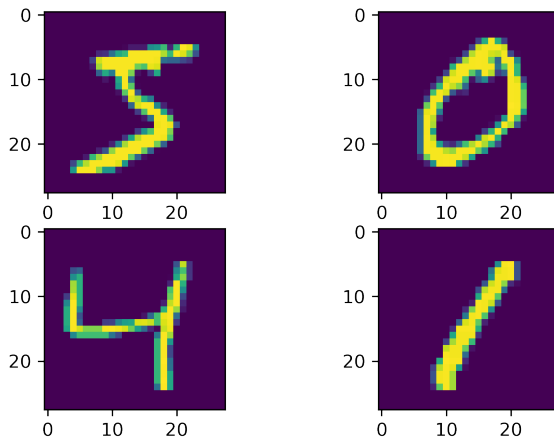
W. Trimble

Due: Friday 2022-04-29 - 11:59pm

Let's look at the MNIST database of handwritten digits. The data are two sets of 60,000 images (28x28 pixel handwritten digits, encoded as 8-bit greyscale images / 1x784 element vectors.)

To get started, you will need to flatten the images into 1-dimensional vectors and put the class labels into one-hot encoding.

1. Display a handful of the images. Find an average image over at least a thousand training samples; display images for the per-digit mean and the per-digit standard deviation pixel values.



2. Train neural networks with 0, 1, and more than 1 hidden layers on the 60,000 MNIST training images. The 0-hidden-layer neural network can be thought of as logistic regression or the single-layer perceptron. Classify the test set and report the confusion matrix on the test set for each of these networks.
3. Find and display the images from a handful of cells in the confusion matrix, say, 4 images at each of 4 confusion-matrix-cells. Which digit pair is hardest to discern?
4. The first layer of the model can be interpreted as weights-per-pixel; it can be interpreted as a linear inner product filter on the input. Take a handful (perhaps 9 or 16) columns from the first-layer weights and display them as images. Are the input weights for the 4-layer model qualitatively different from the input weights for the 1-layer model? Hint: This is an example from the sklearn documentation:

https://scikit-learn.org/stable/auto_examples/neural_networks/plot_mnist_filters.html