

Homework Assignment - 2

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September 14, 2019

Problem Statement. Implement and train a convolution neural network from scratch in Python for the MNIST dataset (no PyTorch). You should write your own code for convolutions (e.g., do not use SciPy's convolution function). The convolution network should have a single hidden layer with multiple channels. It should achieve at least 94% accuracy on the Test Set. For full credit, submit via Compass (1) the code and (2) a paragraph (in a PDF document) which states the Test Accuracy and briefly describes the implementation.

Approach. A single-layer Convolutional neural network with multiple channels has been implemented using the NumPy library in Python 3.

- **Input Dimension** - $28 * 28$
- **Output Dimension** - 10 (MNIST digits)
- **Filter Size** - $3 * 3$
- **# Filters** - 10
- **Epochs** - 30
- **Xavier's** initialization for initial parameter values.
- Decaying schedule used for the learning rate. (Starting from **1e-2** to **1e-5**)
- **ReLU** non-linear activation on the convoluted layer.
- Network trained on **Cross-Entropy loss**.
- Stochastic Gradient Descent (**SGD**) for parameter updates.
- Convolutions computed after flattening the image and filter to speed up the iterations.

Results on MNIST. After 30 epochs, accuracy on test data - **97.05%**.

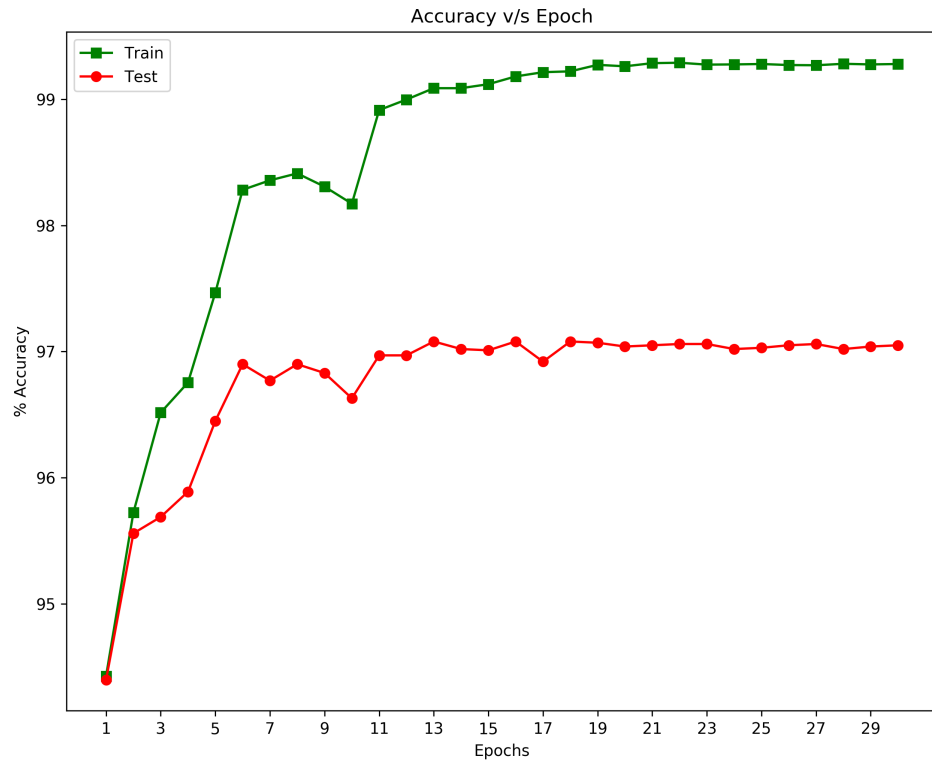
It can be seen through the below summary that the network converges after roughly 20 epochs.

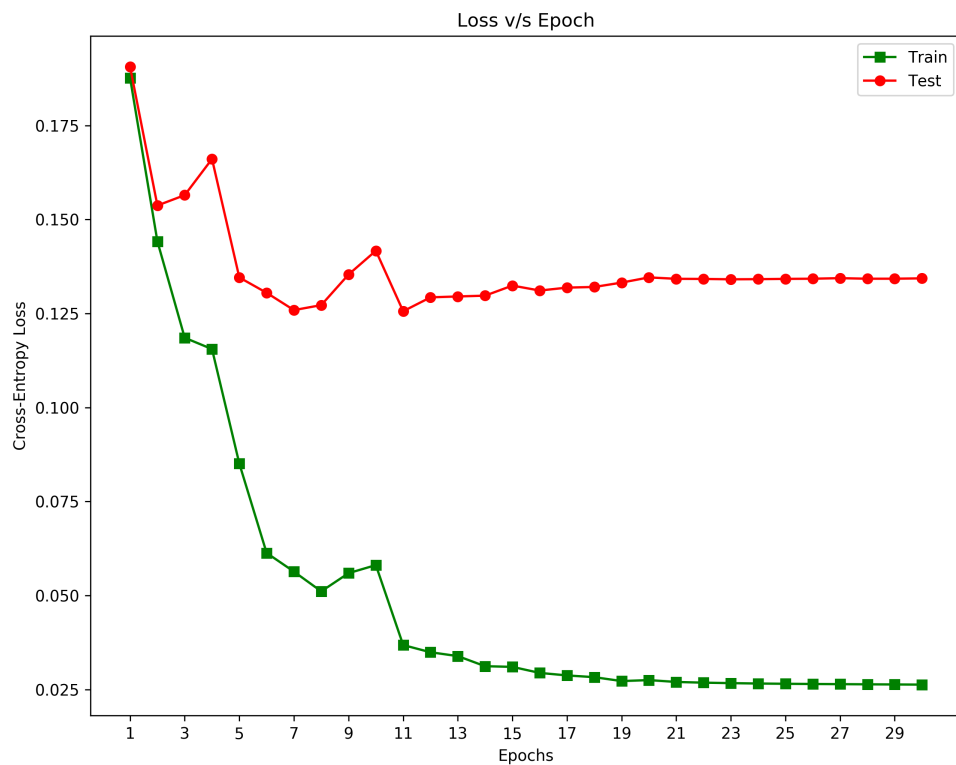
Time taken for the training - *2 hours and 18 minutes*.

Please scroll to the **next page** for loss and accuracy curves.

Epoch 1 - 94.40% test accuracy, 0.1906 test loss, 94.43% train accuracy, 0.1876 train loss.
Epoch 2 - 95.56% test accuracy, 0.1537 test loss, 95.73% train accuracy, 0.1442 train loss.
Epoch 3 - 95.69% test accuracy, 0.1565 test loss, 96.52% train accuracy, 0.1185 train loss.
Epoch 4 - 95.89% test accuracy, 0.1661 test loss, 96.75% train accuracy, 0.1155 train loss.
Epoch 5 - 96.45% test accuracy, 0.1346 test loss, 97.47% train accuracy, 0.0851 train loss.
Epoch 6 - 96.90% test accuracy, 0.1305 test loss, 98.28% train accuracy, 0.0613 train loss.
Epoch 7 - 96.77% test accuracy, 0.1259 test loss, 98.36% train accuracy, 0.0563 train loss.
Epoch 8 - 96.90% test accuracy, 0.1272 test loss, 98.41% train accuracy, 0.0511 train loss.
Epoch 9 - 96.83% test accuracy, 0.1354 test loss, 98.31% train accuracy, 0.0559 train loss.
Epoch 10 - 96.63% test accuracy, 0.1417 test loss, 98.17% train accuracy, 0.0581 train loss.
Epoch 11 - 96.97% test accuracy, 0.1256 test loss, 98.91% train accuracy, 0.0368 train loss.
Epoch 12 - 96.97% test accuracy, 0.1293 test loss, 99.00% train accuracy, 0.0349 train loss.
Epoch 13 - 97.08% test accuracy, 0.1295 test loss, 99.09% train accuracy, 0.0339 train loss.
Epoch 14 - 97.02% test accuracy, 0.1297 test loss, 99.09% train accuracy, 0.0312 train loss.
Epoch 15 - 97.01% test accuracy, 0.1324 test loss, 99.12% train accuracy, 0.0310 train loss.
Epoch 16 - 97.08% test accuracy, 0.1311 test loss, 99.18% train accuracy, 0.0294 train loss.
Epoch 17 - 96.92% test accuracy, 0.1319 test loss, 99.21% train accuracy, 0.0287 train loss.
Epoch 18 - 97.08% test accuracy, 0.1320 test loss, 99.22% train accuracy, 0.0283 train loss.
Epoch 19 - 97.07% test accuracy, 0.1332 test loss, 99.27% train accuracy, 0.0272 train loss.
Epoch 20 - 97.04% test accuracy, 0.1346 test loss, 99.26% train accuracy, 0.0275 train loss.
Epoch 21 - 97.05% test accuracy, 0.1342 test loss, 99.28% train accuracy, 0.0270 train loss.
Epoch 22 - 97.06% test accuracy, 0.1342 test loss, 99.29% train accuracy, 0.0268 train loss.
Epoch 23 - 97.06% test accuracy, 0.1341 test loss, 99.27% train accuracy, 0.0267 train loss.
Epoch 24 - 97.02% test accuracy, 0.1341 test loss, 99.28% train accuracy, 0.0266 train loss.
Epoch 25 - 97.03% test accuracy, 0.1342 test loss, 99.28% train accuracy, 0.0265 train loss.
Epoch 26 - 97.05% test accuracy, 0.1342 test loss, 99.27% train accuracy, 0.0265 train loss.
Epoch 27 - 97.06% test accuracy, 0.1344 test loss, 99.27% train accuracy, 0.0264 train loss.
Epoch 28 - 97.02% test accuracy, 0.1342 test loss, 99.28% train accuracy, 0.0264 train loss.
Epoch 29 - 97.04% test accuracy, 0.1342 test loss, 99.28% train accuracy, 0.0263 train loss.
Epoch 30 - 97.05% test accuracy, 0.1343 test loss, 99.28% train accuracy, 0.0263 train loss.

Time taken for 30 epochs - 8261.011 seconds





End of HW - 2
