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DS 577 Machine Learning in Cyber Security

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### Assignment #1

In this assignment, I implemented a feedforward neural network from Chapter 1 of Nielsen's Neural Networks and Deep Learning to categorize handwritten digits from the MNIST dataset. The network architecture consisted of 784 input neurons (one for each pixel in the  $28 \times 28$  image), one hidden layer with 30 neurons. And 10 output neurons representing the digit classes (0–9). The network was trained using stochastic gradient descent and backpropagation over 30 epochs with a mini-batch amount of 10 and a learning speed of 3.0.

The final model achieved 94.46% accuracy on the 10,000-image test put, demonstrating that the neural network successfully learned to generalize to unseen handwritten digits. This confirms that the utilize of feedforward computation, backpropagation. And stochastic gradient descent was functioning correctly.

#### 1. Network Initialization and Training Setup

```
[(.venv) (base) corrincourville@Corrins-MacBook-Pro cs577-assignment1 % cd src
[(.venv) (base) corrincourville@Corrins-MacBook-Pro src % python3
Python 3.13.9 | packaged by Anaconda, Inc. | (main, Oct 21 2025, 19:11:29) [Clang 20.1.8
] on darwin
Type "help", "copyright", "credits" or "license" for more information.
[>>> import mnist_loader
[>>> training_data, validation_data, test_data = mnist_loader.load_data_wrapper()
/Users/corrincourville/Library/Mobile Documents/com~apple~CloudDocs/wpi_graduate/spring_
2026/DS577-ML&CyberSecurity/assignment1/cs577-assignment1/src/mnist_loader.py:43: Visible
DeprecationWarning: dtype(): align should be passed as Python or NumPy boolean but got
`align=0`. Did you mean to pass a tuple to create a subarray type? (Deprecated NumPy 2.4
)
    training_data, validation_data, test_data = pickle.load(f, encoding="latin1")
[>>> import network
[>>> net = network.Network([784, 30, 10])]
```

## 2. Epoch Output for 30 Hidden Neurons

```
[>>> net.SGD(training_data, 30, 10, 3.0, test_data=test_data)
Epoch 0: 9107 / 10000
Epoch 1: 9216 / 10000
Epoch 2: 9285 / 10000
Epoch 3: 9343 / 10000
Epoch 4: 9327 / 10000
Epoch 5: 9337 / 10000
Epoch 6: 9385 / 10000
Epoch 7: 9386 / 10000
Epoch 8: 9401 / 10000
Epoch 9: 9401 / 10000
Epoch 10: 9386 / 10000
Epoch 11: 9462 / 10000
Epoch 12: 9402 / 10000
Epoch 13: 9457 / 10000
Epoch 14: 9431 / 10000
Epoch 15: 9395 / 10000
Epoch 16: 9438 / 10000
Epoch 17: 9456 / 10000
Epoch 18: 9463 / 10000
Epoch 19: 9448 / 10000
Epoch 20: 9447 / 10000
Epoch 21: 9456 / 10000
Epoch 22: 9404 / 10000
Epoch 23: 9443 / 10000
Epoch 24: 9448 / 10000
Epoch 25: 9464 / 10000
Epoch 26: 9464 / 10000
Epoch 27: 9450 / 10000
Epoch 28: 9451 / 10000
Epoch 29: 9446 / 10000
```