MNIST Digit Classification with Neural Networks

Project Overview

This project explores the use of fully connected neural networks for classifying handwritten digits from the MNIST dataset. The dataset consists of grayscale images of digits (0 through 9), each represented as a 28x28 pixel array. The goal was to build, train, and evaluate different neural network architectures to determine their effectiveness in recognizing digits.

Model Architectures

Several models were tested:
- A 2-layer network: One hidden layer with 512 neurons (ReLU) and an output layer with 10 neurons (softmax).
- An extended network: Added a second hidden layer with 256 neurons (ReLU).
- A dropout-regularized model: Included dropout to prevent overfitting.

All models were trained using the Adam optimizer and the sparse categorical crossentropy loss function. Input data was normalized to the [0, 1] range by dividing pixel values by 255.

Training and Evaluation

The models were trained using a validation split to monitor performance during training. Final evaluation was done on the test set, with accuracy used as the main performance metric. The original 2-layer network achieved the highest test accuracy but showed signs of overfitting, while deeper and regularized models offered more stability and better generalization.

Error Analysis

Misclassified images were visualized to understand where the model struggled. These cases helped identify challenging digits and patterns, such as similar handwriting or ambiguous shapes.

Conclusion

The project demonstrated the impact of neural network architecture on classification performance. While deeper models with regularization improved generalization, the simpler 2-layer model achieved the highest accuracy. This highlights that for certain problems like MNIST, simpler architectures can be both efficient and effective. Further exploration of hyperparameters and advanced techniques may yield additional performance gains.