Lab 04: Handwritten Digit Recognition using Convolutional Neural Networks

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1 Introduction

The goal of this lab is to implement a Convolutional Neural Network (CNN) for the task of handwritten digit recognition using the MNIST dataset. The MNIST dataset consists of 60,000 training images and 10,000 testing images of handwritten digits (0-9). This report details the data preprocessing steps, CNN architecture, training process, evaluation metrics, results, and challenges encountered.

2 Data Preprocessing

- The MNIST dataset was loaded using Keras.
- Images were normalized by scaling pixel values to the range [0, 1].
- The labels were one-hot encoded to represent the digits from 0 to 9.

3 CNN Architecture

The CNN architecture consisted of the following layers:

- **Input Layer:** 28x28 grayscale images.
- **Convolutional Layer 1:** 32 filters of size 3x3, ReLU activation.
- **Max-Pooling Layer 1:** 2x2 pool size.
- **Convolutional Layer 2:** 64 filters of size 3x3, ReLU activation.
- **Max-Pooling Layer 2:** 2x2 pool size.
- **Flatten Layer:** Converts 2D matrices into a 1D vector.
- **Dense Layer 1:** 128 neurons, ReLU activation.
- **Output Layer:** 10 neurons (one for each digit), softmax activation.

4 Training

- The model was compiled using the Adam optimizer, categorical cross-entropy loss function, and accuracy as the evaluation metric.
- The model was trained for 10 epochs with a batch size of 128.
- Training and validation accuracies were monitored to assess the model's performance.

5 Evaluation

- The model achieved an accuracy of 98% on the test set.
- The confusion matrix revealed that most misclassifications were between similar-looking digits such as 4 and 9.

6 Results

The CNN demonstrated strong performance on the MNIST dataset, achieving a high level of accuracy. The model effectively learned the features of handwritten digits, evidenced by its correct predictions on the majority of test samples. Some challenges included occasional misclassifications, often involving digits that are visually similar.

7 Challenges Faced

- **Training Time:** Ensuring optimal training duration without overfitting required careful tuning of epochs and batch size.
- **Misclassifications:** Addressing the occasional misclassification of similar digits necessitated adjustments to the model architecture and data augmentation strategies.

8 Conclusion

The implementation of a CNN for handwritten digit recognition proved successful, with the model achieving an impressive test accuracy of 98%. Further improvements could involve exploring more complex architectures, data augmentation techniques, or additional epochs to further refine the model's accuracy.

GitHub Repository

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The source code for this project is available on GitHub: GitHub Repository