Digit Classification using Convolutional Neural Network (CNN) of MNIST Dataset

MD. NAZMUL HASAN
Department of Computer Science and Engineering
University of Rajshahi
Student ID: 2111176131

September 15, 2025

Abstract

This report presents the implementation and evaluation of a Convolutional Neural Network (CNN) for handwritten digit classification using the MNIST dataset. The dataset consists of grayscale images of digits (0–9). The model was trained using convolutional and fully connected layers, achieving high accuracy on both training and test sets. The experimental results demonstrate the effectiveness of CNNs in image classification tasks.

1 Introduction

Handwritten digit recognition is a fundamental problem in computer vision and machine learning, with applications in digitizing handwritten documents, postal automation, and bank check processing. The MNIST dataset has been widely used as a benchmark for evaluating classification algorithms. In this project, we implemented a Convolutional Neural Network (CNN) to classify handwritten digits.

2 Dataset

The MNIST dataset contains 70,000 grayscale images of handwritten digits (0–9), each of size 28×28 pixels. Among them, 60,000 images are used for training and 10,000 for testing. The dataset is pre-labeled, making it suitable for supervised learning.

3 Methodology

The CNN architecture consists of convolutional, pooling, and fully connected layers. The steps are as follows:

- Normalize the dataset by scaling pixel values between 0 and 1.
- Reshape the dataset to include a channel dimension.

- Build the CNN with:
  1. Conv2D layer with 32 filters of size 3 × 3, ReLU activation.
  2. MaxPooling layer with 2 × 2 pool size.
  3. Conv2D layer with 64 filters of size 3 × 3, ReLU activation.
  4. MaxPooling layer with 2 × 2 pool size.
  5. Flatten layer to convert feature maps into a vector.
  6. Dense layer with 128 neurons and ReLU activation.
  7. Dense layer with 64 neurons and ReLU activation.
  8. Dropout layer (0.5) to prevent overfitting.
  9. Output Dense layer with 10 neurons (softmax activation).
- Compile the model using Adam optimizer and sparse categorical cross-entropy loss.
- Train the model for 5 epochs with batch size of 32.

4 Implementation

The model was implemented in Python using `TensorFlow` and `Keras`. The code includes dataset loading, preprocessing, model definition, training, evaluation, and visualization of results.

The training process was monitored using accuracy and validation accuracy.

5 Results

The model achieved strong performance on the MNIST dataset:

- Training accuracy: Above 98% after 5 epochs.
- Test accuracy: Approximately 99%.

5.1 Training History

Figure 1 shows the training and validation accuracy across epochs.

5.2 Sample Predictions

Figure 2 shows some test images with their predicted and true labels. The model correctly classified most of the samples.

6 Conclusion

In this project, we successfully implemented a Convolutional Neural Network for handwritten digit classification using the MNIST dataset. The model achieved high accuracy, validating the effectiveness of CNNs for image recognition tasks. Future work may involve experimenting with deeper architectures, regularization methods, or applying transfer learning for improved performance.

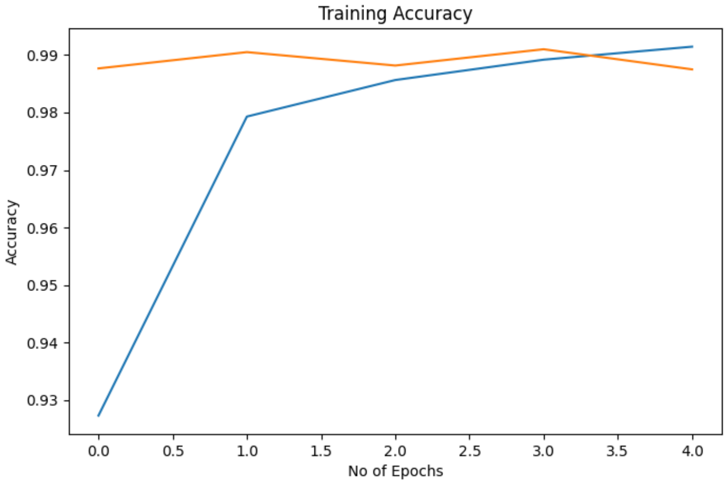

Figure 1: Training and validation accuracy over 5 epochs.

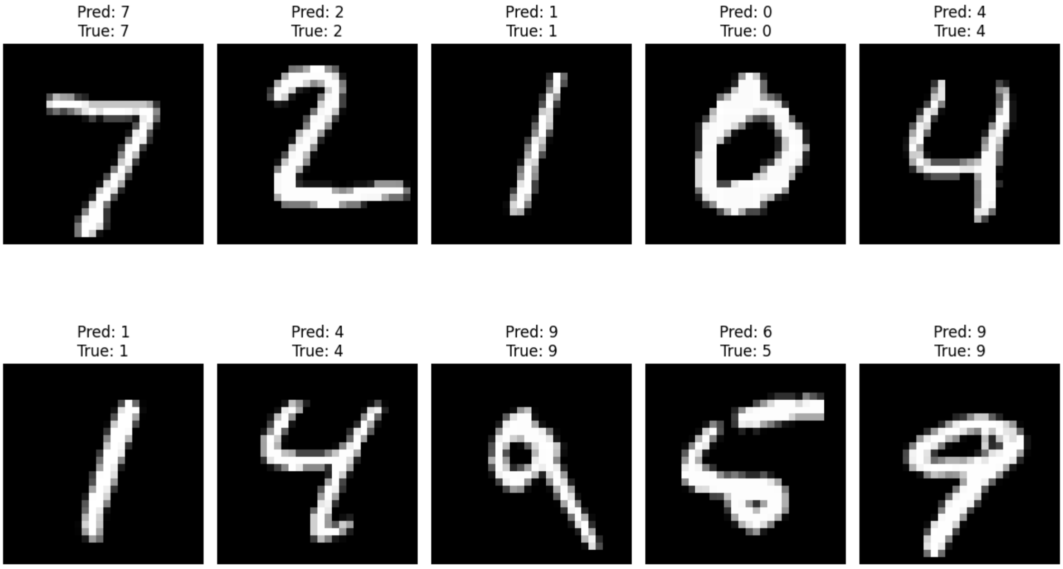

Figure 2: Sample test images with predicted and true labels.

7 Code Resources

The implementation of the 10-class MNIST classification model, including training and evaluation scripts, is available through the following platforms:

- GitHub: Click here
- Google Colab: Click here