MNIST Handwritten Digit Recognition Project Report

# 1. Problem Statement

The goal of this project is to build a machine learning model that can accurately recognize handwritten digits from the MNIST dataset. The project involves data exploration, image preprocessing, model training, evaluation, and comparison to find the best-performing classifier.

# 2. Dataset Description

The MNIST dataset consists of 70,000 grayscale images of handwritten digits ranging from 0 to 9. Each image is of size 28x28 pixels. The dataset is split into 60,000 training samples and 10,000 test samples.

# 3. Exploratory Data Analysis (EDA)

- Displayed dataset shape and dimensions.

- Verified that labels are evenly distributed across all digit classes.

- Visualized random samples from the training dataset.

- Analyzed pixel intensity values to confirm grayscale range (0–255).

# 4. Data Preprocessing

- Normalized pixel values by dividing by 255 to bring them into [0, 1] range.

- Reshaped the image data to add channel dimension (28x28x1).

- Prepared the labels for classification using integer encoding.

# 5. Model Development

We implemented and trained multiple models to classify handwritten digits:

1. Fully Connected Neural Network (MLP):

- Layers: Flatten → Dense(128, ReLU) → Dense(10, Softmax)

- Optimizer: Adam | Loss: Sparse Categorical Crossentropy

2. Convolutional Neural Network (CNN):

- Layers: Conv2D → MaxPooling2D → Flatten → Dense → Output

- Conv2D: Extracts spatial features using filters

- MaxPooling2D: Reduces spatial dimensions

- Flatten: Converts 2D feature maps into 1D vector

- Dense: Fully connected layers for classification

# 6. Model Training

- Models trained using the Adam optimizer with 5-10 epochs.

- Used training-validation split to monitor overfitting.

- Tracked accuracy and loss over training and validation sets.

# 7. Model Evaluation

- Evaluated models on test data using accuracy score.

- Generated confusion matrix and classification report for detailed insights.

- Observed ~97% accuracy for MLP and ~99% accuracy for CNN.

# 8. Model Comparison

Comparison of key models:

- MLP: Simpler and faster to train, but slightly lower accuracy.

- CNN: More accurate due to spatial feature learning, slightly more complex.

# 9. Conclusion

The CNN model proved to be the best-performing model for handwritten digit recognition on the MNIST dataset, achieving ~99% accuracy. The project demonstrates the power of convolutional architectures for image classification tasks.