**Handwritten Digit Classification Using MLP**

**1. Introduction**

This project aims to develop a handwritten digit classifier using a **Multilayer Perceptron (MLP)** trained on the **MNIST dataset**. The MNIST dataset contains 70,000 grayscale images of handwritten digits (0 to 9), with 60,000 for training and 10,000 for testing. Each image is 28×28 pixels.

**2. Dataset Details**

* **Name:** MNIST (Modified National Institute of Standards and Technology)
* **Image Size:** 28×28 pixels (grayscale)
* **Total Samples:** 70,000
  + **Training:** 60,000
  + **Testing:** 10,000
* **Classes:** 10 (digits 0 to 9)

**3. Preprocessing**

* **Normalization:** All pixel values scaled from 0–255 to 0–1.
* **Reshaping:** Each 28×28 image was flattened into a 784-dimensional vector.
* **One-Hot Encoding:** Labels were converted to one-hot encoded vectors for multi-class classification.

**4. MLP Model Architecture**

The MLP model was built using the **TensorFlow/Keras** library with the following architecture:

| **Layer Type** | **Units** | **Activation** |
| --- | --- | --- |
| Dense (Input) | 256 | ReLU |
| Dense (Hidden) | 128 | ReLU |
| Dense (Hidden) | 64 | ReLU |
| Dense (Output) | 10 | Softmax |

* **Loss Function:** Categorical Crossentropy
* **Optimizer:** Adam
* **Metrics:** Accuracy
* **Epochs:** 10
* **Batch Size:** 128
* **Validation Split:** 20%

**5. Training Summary**

| **Epoch** | **Training Accuracy** | **Validation Accuracy** | **Training Loss** | **Validation Loss** |
| --- | --- | --- | --- | --- |
| 1 | 0.9098 | 0.9581 | 0.3162 | 0.1428 |
| 5 | 0.9874 | 0.9757 | 0.0398 | 0.0810 |
| 10 | 0.9943 | 0.9738 | 0.0165 | 0.1125 |

* **Final Test Accuracy:** 97.52%

**6. Evaluation Metrics**

**Confusion Matrix**

A confusion matrix was generated to visualize classification performance. It showed:

* High accuracy across all digits
* Very few misclassifications
* Slight confusion between similar digits like **3 & 5** or **4 & 9**

**Classification Report**

| **Metric** | **Value (Macro Avg)** |
| --- | --- |
| Precision | 0.98 |
| Recall | 0.97 |
| F1-Score | 0.97 |
| Overall Accuracy | 0.98 |

**Sample Predictions**

10 sample predictions were displayed with images showing both true and predicted labels. The model correctly classified most samples.

**7. Accuracy Plot**

A line plot of training and validation accuracy over epochs showed:

* Continuous improvement during early epochs
* Slight overfitting after epoch 6–7

**8. Conclusion**

The MLP achieved **97.5% accuracy** on the test set, proving that a deep, fully connected network with ReLU activation and softmax output is capable of high performance on digit classification tasks.

While CNNs generally perform better on image data due to spatial feature extraction, this MLP shows strong results for a baseline model.