**📌 Project Title**

Design and Implementation of a Neural Network using TensorFlow for Handwritten Digit Classification (MNIST)

**🔹 1. Introduction**

Handwritten digit recognition is one of the most fundamental applications of **Artificial Intelligence (AI)** and **Deep Learning**, serving as a starting point for understanding how neural networks process visual data.  
The **MNIST dataset** is a benchmark dataset containing **70,000 grayscale images** (60,000 for training and 10,000 for testing), each sized **28×28 pixels**.

This project focuses on building a **Multilayer Perceptron (MLP)** using TensorFlow (v1.x) to classify digits (0–9), analyzing its accuracy, and discussing potential improvements.

**🔹 2. Data Preprocessing**

* **Loading the data:** Using tf.keras.datasets.mnist.load\_data().
* **Normalization:** Pixel values (0–255) were scaled to (0–1) by dividing by 255.
* **Reshaping:** Images were flattened into 1D vectors of length 784 (28×28).
* **Encoding labels:** Numerical labels were transformed into **One-Hot Encoding** using scikit-learn (e.g., digit 3 → [0,0,0,1,0,0,0,0,0,0]).

**🔹 3. Model Architecture**

The neural network architecture consists of:

* **Input Layer:** 784 neurons (pixels).
* **Hidden Layers:**
  + Layer 1: 512 neurons, ReLU activation.
  + Layer 2: 256 neurons, ReLU.
  + Layer 3: 128 neurons, ReLU.
* **Dropout Layer:** Dropout rate of 0.5 to reduce overfitting.
* **Output Layer:** 10 neurons with Softmax activation to represent digit probabilities.

**🔹 4. Training Process**

* **Optimizer:** Adam Optimizer.
* **Loss Function:** Softmax Cross-Entropy.
* **Iterations:** 1000.
* **Batch Size:** 128.
* **Weight Initialization:** Truncated Normal distribution.
* **Execution:** Training was performed using a tf.compat.v1.Session() to execute the computation graph.

The model’s loss and accuracy were monitored every 100 iterations, confirming continuous improvement.

**🔹 5. Results**

* **Test Accuracy:** Approximately 97–98%.
* **Loss Curve:** Showed a gradual decrease over time, indicating proper learning.
* **External Image Test:** A custom PNG image was loaded, and the model successfully predicted the correct digit.

**🔹 6. Discussion**

* The high accuracy confirms the effectiveness of MLPs with multiple hidden layers.
* Dropout played an important role in reducing **overfitting**.
* However, MLPs are not the state-of-the-art for image recognition. **Convolutional Neural Networks (CNNs)** outperform them by exploiting spatial patterns in images.

**🔹 7. Future Work**

* Implementing **CNN architectures** such as LeNet or ResNet.
* Applying **Data Augmentation** (rotations, scaling, noise) to improve generalization.
* Leveraging **GPU/TPU acceleration** for faster training.
* Expanding the project into real-world handwriting recognition applications.