PROJECT REPORT

MNIST Digit Classification using Artificial Neural Network

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Submitted To: Navoitech Solution Pvt Ltd

Submission Date: 4th March 2026

1. Introduction

Machine Learning and Deep Learning have become essential technologies in solving real-world problems. One of the fundamental tasks in computer vision is image classification.

This project focuses on classifying handwritten digits using the MNIST dataset. The goal is to build an Artificial Neural Network (ANN) model that can accurately recognize digits (0–9) from grayscale images.

The MNIST dataset is widely used as a benchmark dataset for image classification problems.

2. Objective

The main objectives of this project are:

- To understand image classification using neural networks
- To preprocess image data for model training
- To build an Artificial Neural Network using TensorFlow and Keras
- To train and evaluate the model
- To achieve high accuracy on unseen test data

3. Dataset Description

The dataset used in this project is the MNIST handwritten digit dataset.

Dataset Details:

- Total Training Images: 60,000
- Total Testing Images: 10,000
- Image Size: 28 × 28 pixels
- Image Type: Grayscale
- Number of Classes: 10 (Digits 0–9)

Each image contains a handwritten digit centered in a 28x28 pixel frame.

4. Tools and Technologies Used

- Python
- Google Colab

- NumPy
- Matplotlib
- TensorFlow
- Keras
- Scikit-learn

5. Data Preprocessing

Before training the model, the following preprocessing steps were performed:

5.1 Normalization

Pixel values originally ranged from 0 to 255.
They were scaled to range between 0 and 1 by dividing by 255.

This helps the neural network train faster and more efficiently.

5.2 Train-Test Split

The dataset was already divided into training and testing sets:

- Training Set: 60,000 images
- Testing Set: 10,000 images

6. Model Architecture

An Artificial Neural Network (ANN) was built using the Sequential model.

Layers Used:

1. Input Layer (Flatten Layer)
   Converts 28×28 images into a 1D vector of 784 neurons.
2. Hidden Layer
   - Dense layer with 128 neurons
   - Activation function: ReLU
3. Output Layer
   - Dense layer with 10 neurons
   - Activation function: Softmax

The Softmax function outputs probabilities for each digit class.

7. Model Compilation

The model was compiled using:

- Optimizer: Adam
- Loss Function: Sparse Categorical Crossentropy
- Evaluation Metric: Accuracy

8. Model Training

The model was trained using:

- Epochs: 5
- Validation Split: 10%

During training, both accuracy and loss were monitored.

Training accuracy increased steadily across epochs, indicating successful learning.

9. Model Evaluation

After training, the model was evaluated on the test dataset.

Test Accuracy Achieved:

Approximately **97.8%**

This indicates that the model correctly classifies most handwritten digits.

10. Confusion Matrix

A confusion matrix was generated to evaluate class-wise performance.

The confusion matrix shows how many digits were correctly and incorrectly classified for each class.

Most digits were classified correctly, showing strong performance of the neural network.

11. Sample Prediction

A sample test image was selected and passed through the model.

The predicted digit matched the actual digit, demonstrating practical usability of the trained model.

12. Results

- Training Accuracy: ~98%
- Test Accuracy: ~97.8%
- Model successfully classified handwritten digits
- Low error rate observed

The model performs very efficiently for a simple ANN architecture.

13. Conclusion

In this project, an Artificial Neural Network was successfully developed to classify handwritten digits from the MNIST dataset.

The model achieved a high test accuracy of approximately **97.8%,** demonstrating strong performance in image classification tasks.

Through this project, practical understanding was gained

- Data preprocessing and normalization
- Neural network architecture design
- Model training and evaluation
- Performance analysis using accuracy and confusion matrix

The results confirm that Artificial Neural Networks are highly effective for solving handwritten digit recognition problems.