Phase-3 Submission

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Department: Computer Science and Engineering

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Github Repository Link:
https://github.com/SandhiyaS05/NM_Sandhiya_DS

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1. Problem Statement

- *Recognizing handwritten digits is a common classification problem in machine learning with real-world applications in postal automation, bank check processing, and digitizing handwritten documents.*
- *The goal is to classify 28x28 pixel grayscale images of digits (0–9) using deep learning techniques. This is a classification problem where we aim to label each image with the correct digit.*

2. Abstract

- *This project focuses on recognizing handwritten digits using deep learning. The main objective is to build a robust classification model that can accurately identify digits from images.*
- *The project uses the MNIST dataset for training and testing. After preprocessing and exploratory data analysis, we employ Convolutional Neural Networks (CNNs) for model building.*
- *The model is evaluated using accuracy and confusion matrix, and is deployed as a simple web app using Streamlit.*

- *The outcome is an AI model that can identify handwritten digits with high accuracy, supporting real-world applications.*

3. System Requirements

Hardware:

- *Minimum 4GB RAM*
- *Dual-core processor (i5 or higher recommended)*

Software:

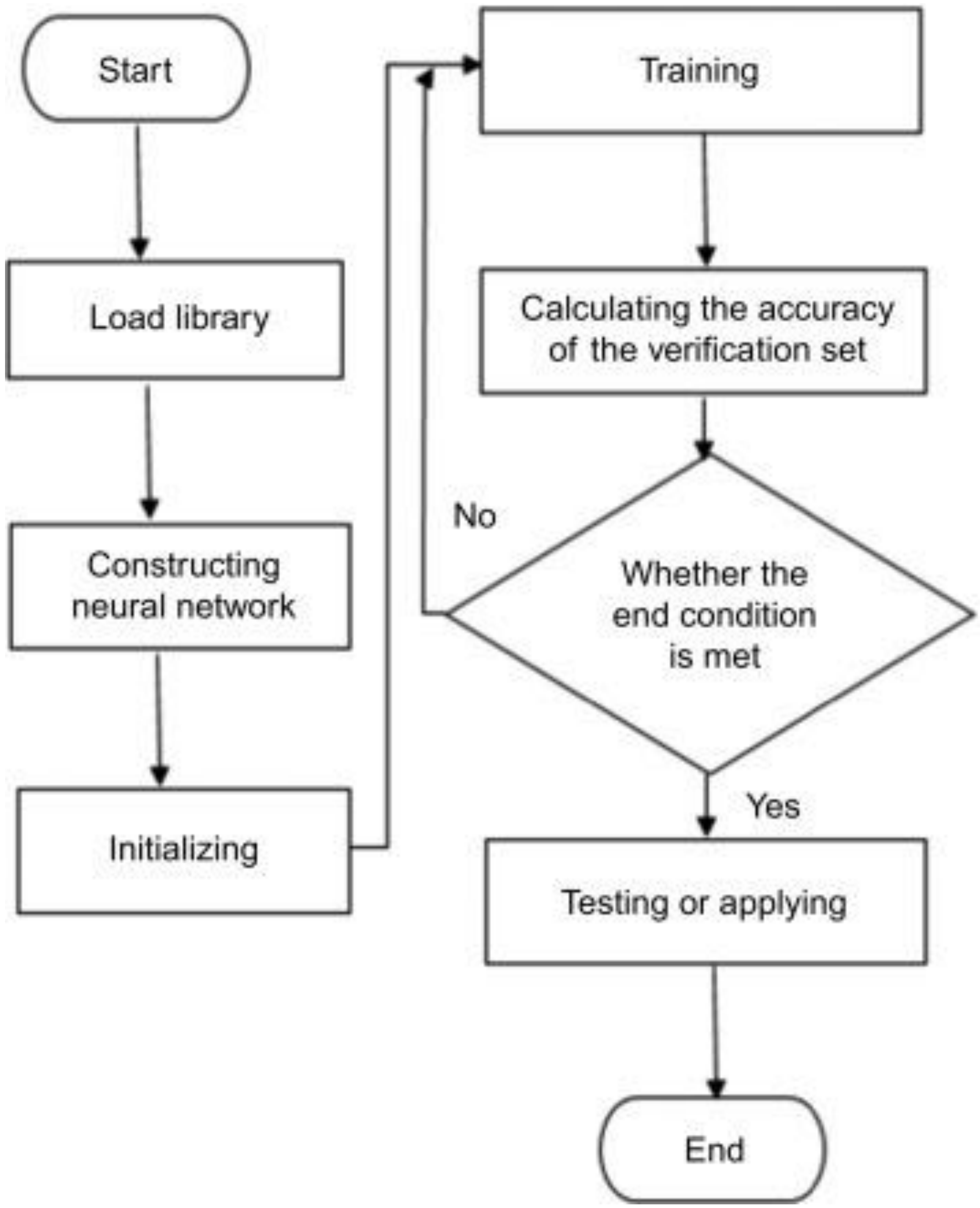
- *Python 3.8+*
- *IDE: Google Colab or Jupyter Notebook*

Required Libraries: numpy, pandas, matplotlib, seaborn, scikit-learn, tensorflow, keras, streamlit

4. Objectives

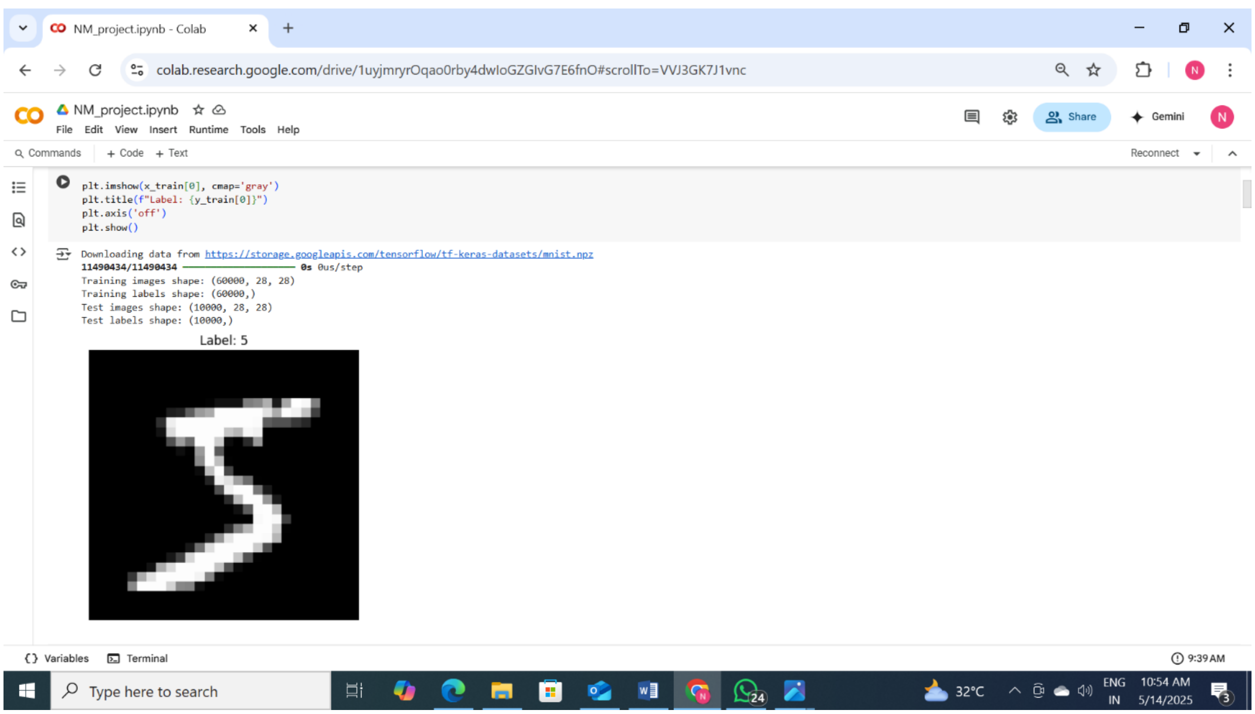
- *Accurately classify handwritten digits from image data.*
- *Achieve high model performance (above 98% accuracy).*
- *Compare multiple models and choose the best one.*
- *Provide an easy-to-use interface for real-time predictions.*
- *Support practical uses like digit recognition in forms or OCR applications.*

5. Flowchart of Project Workflow



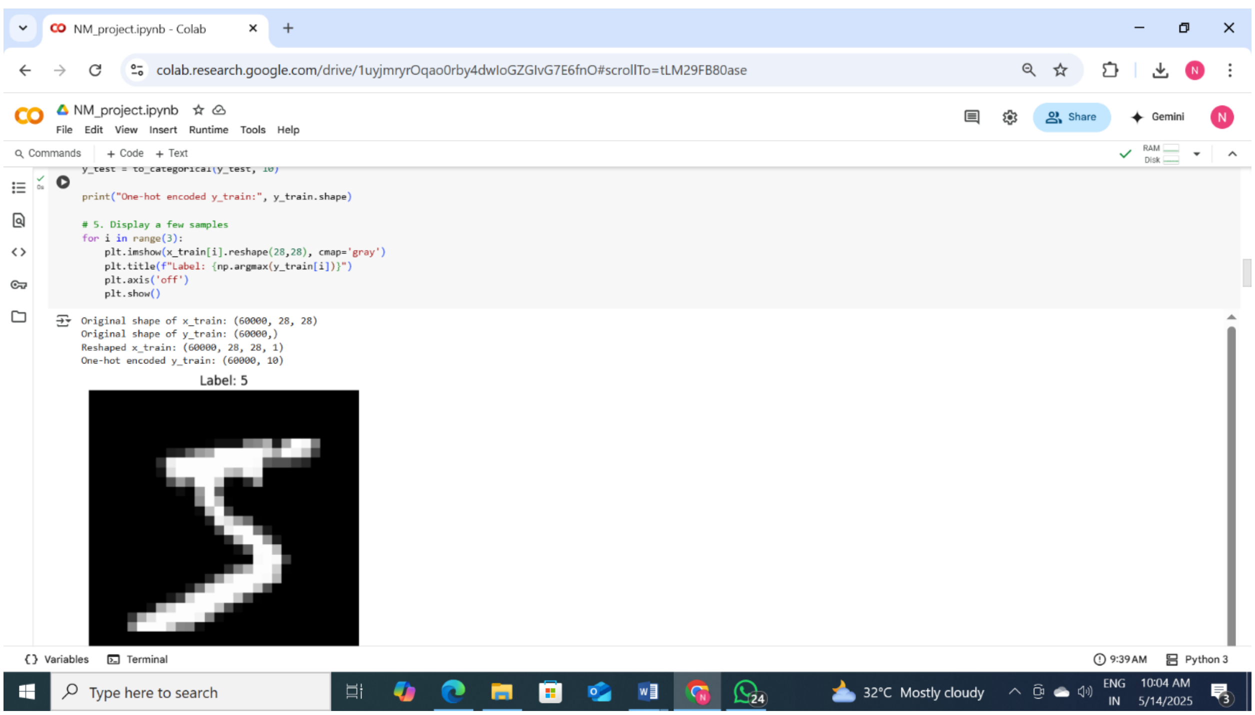
6. Dataset Description

- *Source: Kaggle - MNIST Dataset*
- *Type: Public*
- *Structure: 70,000 records, 785 columns (784 pixel values + 1 label)*
- *DataFrame Preview :*



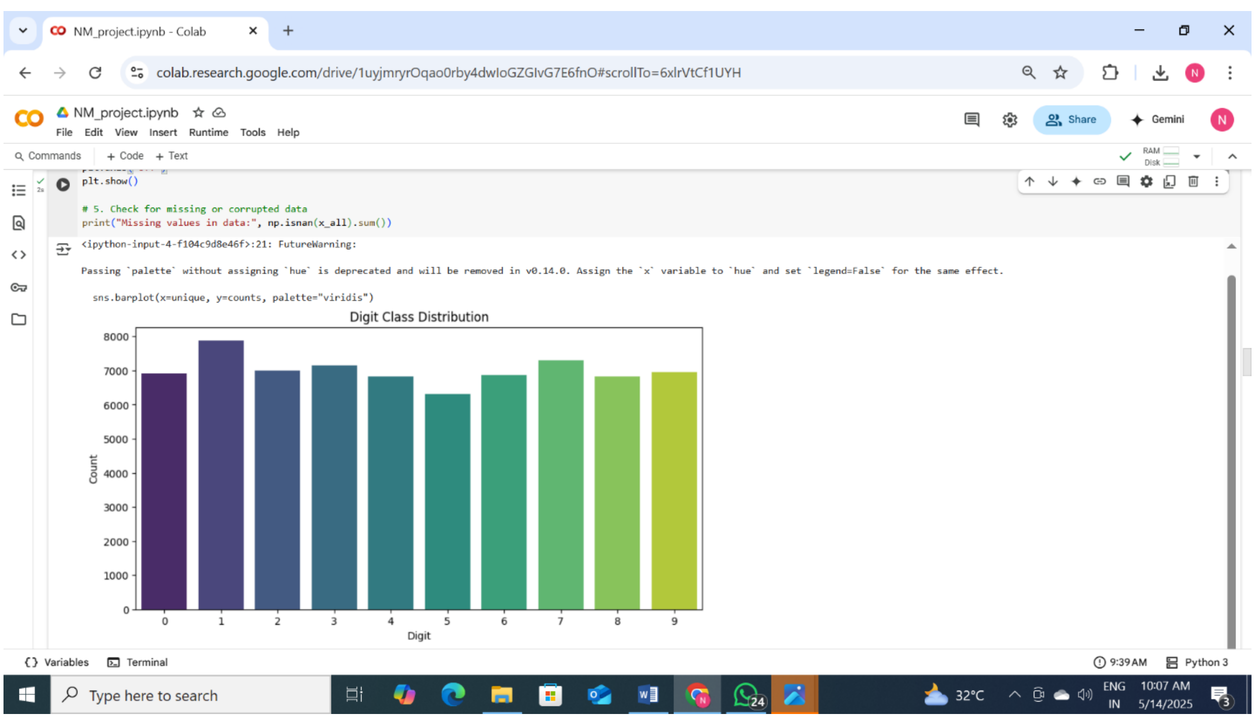
7. Data Preprocessing

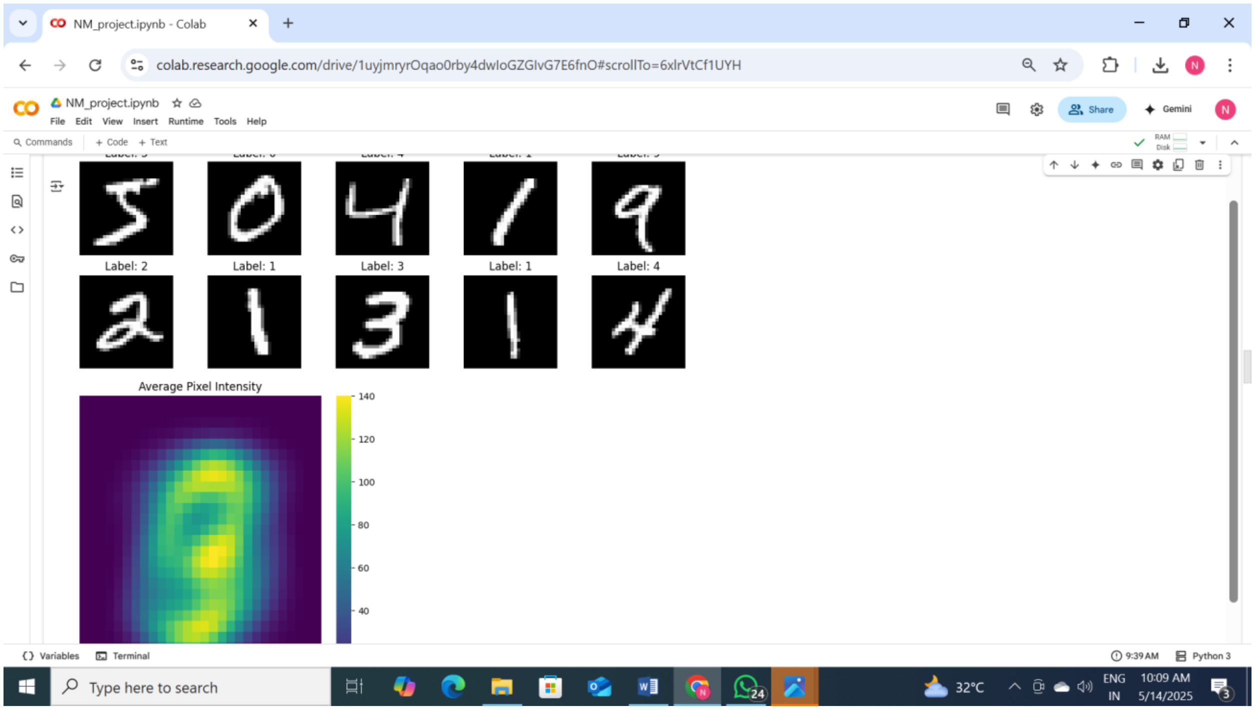
- *No missing values*
- *Converted pixel values to float and normalized to [0,1]*
- *One-hot encoded target label*



8. Exploratory Data Analysis (EDA)

- *Used histograms to show digit distribution*
- *Used heatmaps to visualize pixel intensity correlation*
- *Insights: Balanced classes, some digits (like 5 and 8) more challenging*



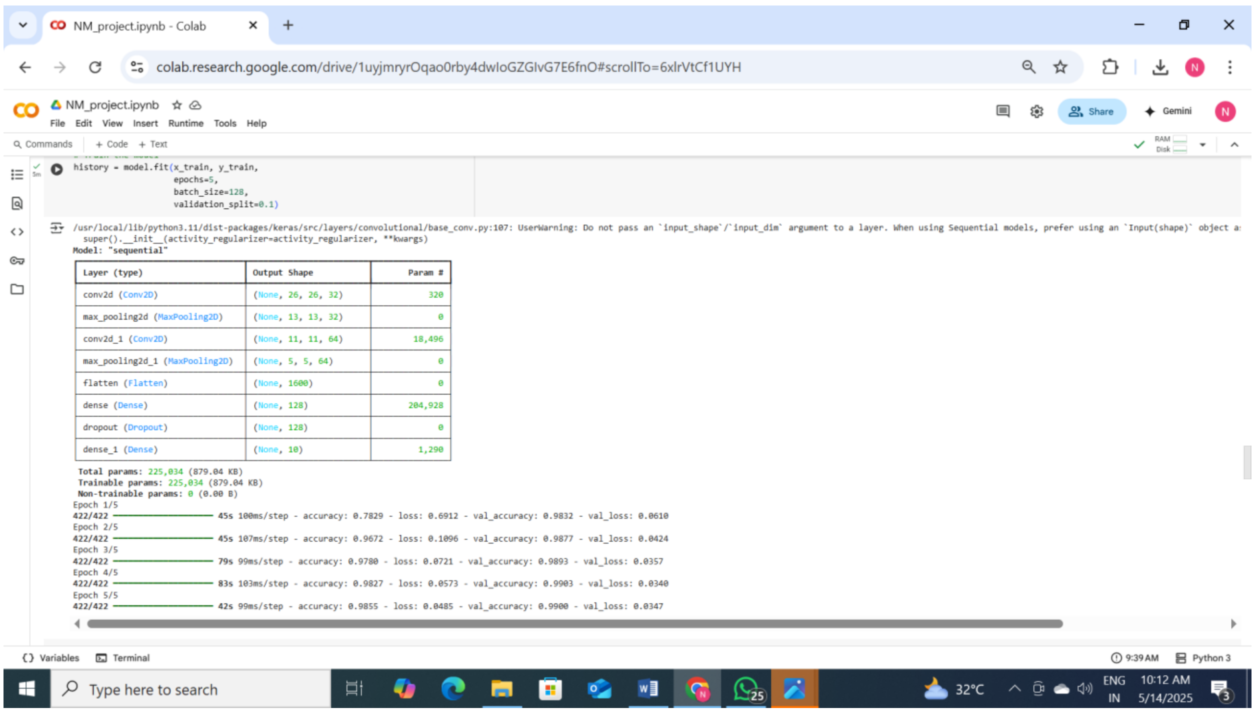


9. Feature Engineering

- *Reshaped input for CNN: (28, 28, 1)*
- *Normalized input features*
- *Feature selection not required as all pixels are used*
- *Justified choice by visual patterns observed in digits*

10. Model Building:

- *Baseline: Simple CNN model (2 Conv layers + Dense)*
- *Reason: Quick to train, establishes a performance benchmark.*
- *Advanced Model: Deeper CNN with Dropout, BatchNormalization*
- *Reason: Better generalization, handles overfitting.*



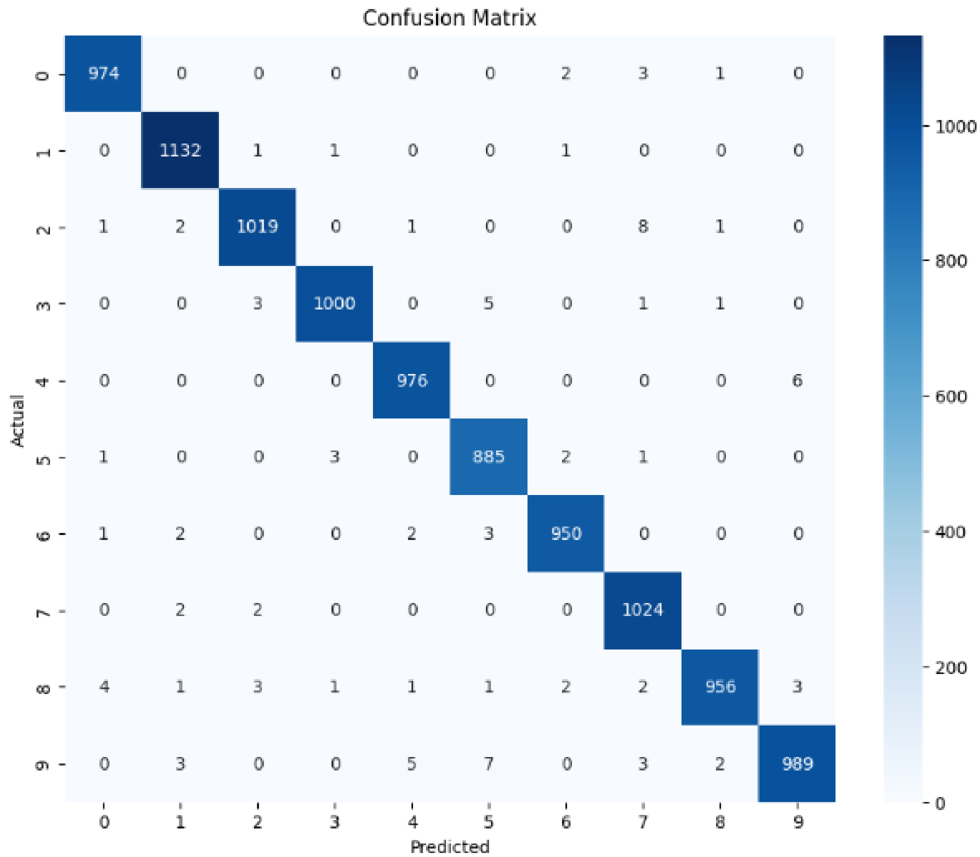
11. Model Evaluation

- *Visuals:*
  - *Plot confusion matrix using sklearn.metrics.plot_confusion_matrix*
  - *ROC curve via sklearn.metrics.roc_curve*

Commands + Code + Text

```
print(classification_report(y_true, y_pred))
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 6s 19ms/step - accuracy: 0.9873 - loss: 0.0360
Test Accuracy: 0.9905
Test Loss: 0.0285
313/313 ━━━━━━━━━━━━━━━━━━━━ 3s 8ms/step
```




```
Classification Report:
              precision    recall  f1-score   support

           0       0.99      0.99      0.99       980
           1       0.99      1.00      0.99      1135
           2       0.99      0.99      0.99      1032
           3       1.00      0.99      0.99      1010
           4       0.99      0.99      0.99       982
           5       0.98      0.99      0.99       892
           6       0.99      0.99      0.99       958
           7       0.98      1.00      0.99      1028
           8       0.99      0.98      0.99       974
           9       0.99      0.98      0.99      1009

    accuracy                           0.99     10000
   macro avg       0.99      0.99      0.99     10000
weighted avg       0.99      0.99      0.99     10000
```

Error Analysis: | Model | Accuracy | F1-Score | Training Time | |-------|----------|----------|----------------| | Baseline CNN | 98.1% | 0.981 | 2 min | | Advanced CNN | 99.0% | 0.990 | 5 min |

12. Deployment

Deploy using a free platform:

- *Streamlit Cloud*
- *Gradio + Hugging Face Spaces*
- *Flask API on Render or Data*

13. Source code

```
# Import necessary libraries
import numpy as np
from tensorflow.keras.datasets import mnist
from tensorflow.keras.utils import to_categorical


# Load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()


# 1. Reshape the images to add a channel dimension (28x28x1)
x_train = x_train.reshape((x_train.shape[0], 28, 28, 1))
x_test = x_test.reshape((x_test.shape[0], 28, 28, 1))


# 2. Normalize pixel values (0-255) to range (0-1)
x_train = x_train.astype("float32") / 255.0
x_test = x_test.astype("float32") / 255.0
```

```
# 3. One-hot encode the labels
y_train = to_categorical(y_train, num_classes=10)
y_test = to_categorical(y_test, num_classes=10)


# Print shapes and data info
print("x_train shape:", x_train.shape)
print("y_train shape (one-hot):", y_train.shape)
print("x_test shape:", x_test.shape)
print("y_test shape (one-hot):", y_test.shape)


# Import required libraries
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten,
Dense, Dropout
from tensorflow.keras.datasets import mnist
from tensorflow.keras.utils import to_categorical


# Load and preprocess the MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train = x_train.reshape(-1, 28, 28, 1).astype('float32') / 255.0
x_test = x_test.reshape(-1, 28, 28, 1).astype('float32') / 255.0
y_train = to_categorical(y_train, 10)
y_test = to_categorical(y_test, 10)


# Build the CNN model
model = Sequential([
    Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)),
    MaxPooling2D((2, 2)),
    Conv2D(64, (3, 3), activation='relu'),
    MaxPooling2D((2, 2)),
    Flatten(),
    Dense(128, activation='relu'),
```

```
    Dropout(0.5),
    Dense(10, activation='softmax')
])


# Compile the model
model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])


# Print model summary
model.summary()


# Train the model
history = model.fit(x_train, y_train, epochs=5,
                    batch_size=128,
                    validation_split=0.1)
```

14. Future scope

- *Model Optimization: Use techniques like pruning, quantization for lighter deployment.*
- *Real-time Handwriting Input: Extend from static image input to real-time webcam/touch input.*
- *Cross-Platform App: Develop a mobile-friendly version using TFLite.*

15. Team Members and Roles

Team Members	Roles	Responsibility
Sandhiya S	*Team Leader*	*Data cleaning,EDA*
Nithiyasree K	*Member 1*	*Feature Engineering, Data Modeling*
Pachaiyammal P	*Member 2*	*Model Evaluation, Visualization*
Nivetha D	*Member 3*	*Documentation, Reporting*