Phase-2 Submission

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Github Repository Link:
https://github.com/Nive643/NM_Nivetha_DS

RECOGNIZING HANDWRITTEN DIGITS WITH DEEP LEARNING FOR SMARTER AI APPLICATIONS

1. Problem Statement

Handwritten digit recognition is a common challenge in real-world applications like postal mail sorting, form processing, and banking. However, due to the variability in handwriting styles, creating a reliable recognition system is not straightforward.

This project addresses a classification problem, where the goal is to correctly identify digits (0–9) from images of handwritten text. By using deep learning, specifically convolutional neural networks (CNNs), we aim to improve recognition accuracy and build an intelligent system that mimics human perception.

Solving this problem is important because it enhances automation in several industries, reduces manual errors, and helps in building smarter AI-powered systems that interact with handwritten input.

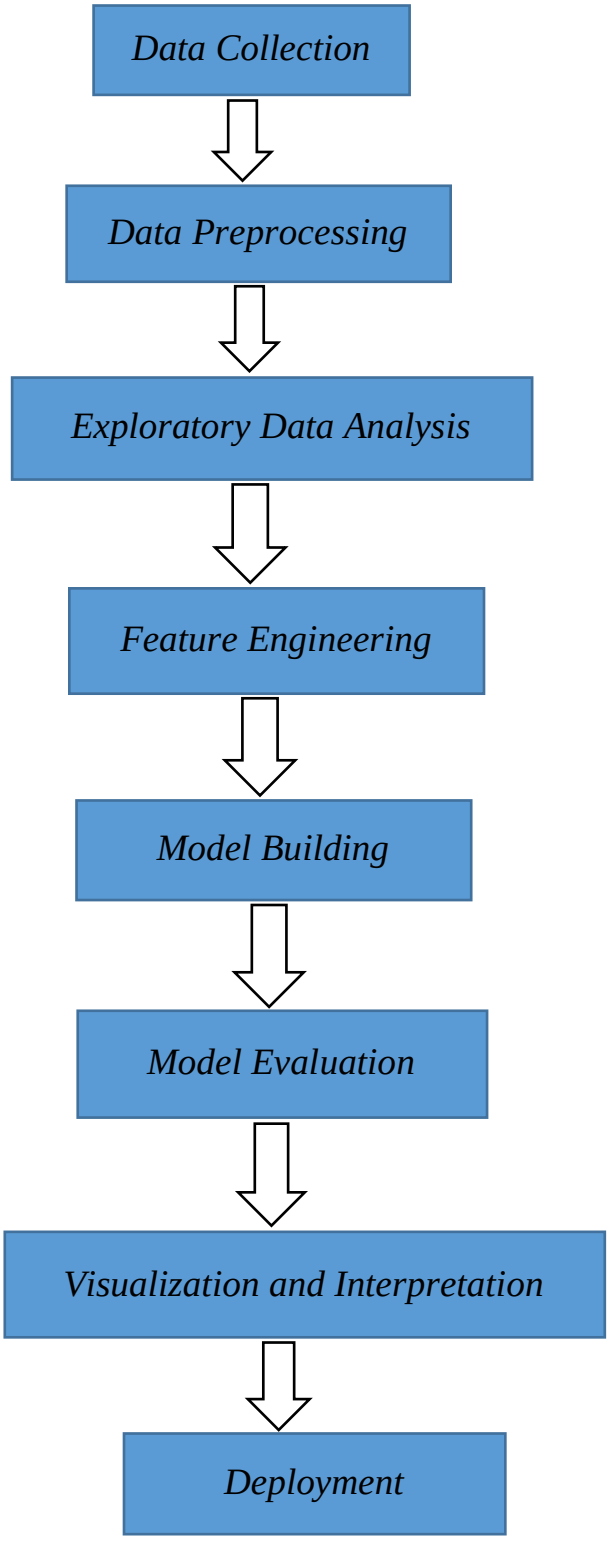
2. Project Objectives

The primary goal of this project is to develop a robust deep learning model capable of recognizing handwritten digits with high accuracy. Key technical objectives include:

- *Achieving a classification accuracy of at least 95%.*
- *Building a convolutional neural network (CNN) optimized for image classification.*
- *Comparing deep learning performance with traditional machine learning models.*
- *Ensuring model interpretability through visualization of feature importance and prediction confidence.*
- *Make the model fast and efficient.*
- *Reduce errors in digit prediction.*

These goals have been refined after EDA revealed consistent patterns in pixel intensity distributions across digit classes.

3. Flowchart of the Project Workflow



4. Data Description

- *Dataset Name: MNIST Handwritten Digits*
- *Source: Kaggle [https://www.kaggle.com/datasets/oddrationale/mnist-in-csv]*
- *Type of Data: Image (grayscale), structured*
- *Records and Features: 70,000 records, each with 784 features (28x28 pixels) + 1 target variable (label)*
- *Static or Dynamic: Static*
- *Target Variable: Digit label (0–9)*

5. Data Preprocessing

- *Missing Values: None found*
- *Duplicate Records: Checked and removed if any*
- *Outliers: Not applicable (pixel values range from 0–255 only)*
- *Data Type Conversion: Images flattened into 784-length arrays*
- *Encoding: Target is already numeric*
- *Normalization: Pixel values scaled to [0,1] range for faster model convergence*

6. Exploratory Data Analysis (EDA)

- *Univariate: Histograms of pixel intensities*
- *Bivariate/Multivariate: Correlation heatmap of pixels*
- *Target Relationship: Visualized average digit images for each label*
- *Insights:*
  - *Digits have distinct central pixel activation*
  - *Some digits (like 3 and 5) have overlapping pixel patterns*

7. Feature Engineering

- *Created pixel intensity histograms per image*
- *Introduced average stroke width feature (optional)*
- *No dimensionality reduction yet, but PCA is considered for testing*

8. Model Building

- *Models: Logistic Regression, CNN (Keras/TensorFlow)*
- *Data Split: 80/20 train-test*
- *CNN Architecture:*
  - *Conv2D + ReLU*

- *MaxPooling2D*
- *Flatten + Dense*
- *Softmax Output Layer*

- *Metrics: Accuracy, Precision, Recall, F1-score*

9. Visualization of Results & Model Insights

- *Confusion Matrix: To assess model prediction errors*
- *ROC Curve: For binary sub-class comparisons*
- *Feature Maps: To interpret CNN filters*
- *Accuracy/Loss Curves: Model training history*

10. Tools and Technologies Used

- *Programming Language: Python*
- *IDE/Notebook: Google Colab*
- *Libraries: pandas, numpy, seaborn, matplotlib, scikit-learn, TensorFlow, Keras*
- *Visualization Tools: Matplotlib, Seaborn*

11. Team Members and Contributions

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*