

## PHASE-2

### RECOGNIZING HANDWRITTEN DIGITS ]WITH DEEP LEARNING FOR SMARTER AI APPLICATIONS

- o Student Name: [T.Agilesh]
- o Register Number: [422623104702]
- o Institution: [University College Of Engineering Panruti]
- o Department: [Computer Science And Engineering]
- o Date of Submission: [10.05.2025]
- o Github Repository Link:  
[<https://github.com/Agilesh456/Recognizing-handwritten-digits-with-deep-learning-for-smarter-AI-applications.git>]

#### 1. PROBLEM STATEMENT:

- ✓ In many industries including finance, education, and logistics, there is a growing need to convert handwritten numeric data into machine-readable formats quickly and accurately. Manual transcription is inefficient and error-prone. This project aims to build a deep learning-based system that can automatically recognize handwritten digits (0–9) using Convolutional Neural Networks (CNNs). By training the model on the MNIST dataset, the system demonstrates real-time digit recognition capabilities with high accuracy, suitable for smart OCR applications.
- ✓ Problem Type: Classification (multi-class)
- ✓ Why it matters: Enables smarter, automated systems for processing handwritten forms, checks, exam sheets, and more, reducing errors and increasing efficiency.

## 2. PROJECT OBJECTIVES:

- ✓ Develop a CNN model to classify handwritten digits (0–9) from image data.
- ✓ Achieve a classification accuracy of >98% on the MNIST test set.
- ✓ Ensure the model is generalizable and applicable in real-world OCR scenarios.
- ✓ Compare performance with traditional ML models like Logistic Regression and Random Forest.
- ✓ Provide visual explanations (e.g., confusion matrix, activation maps) to interpret model behavior.

## 3. FLOWCHART OF THE PROJECT WORKFLOW

Start



Data Collection (MNIST Dataset)



Data Preprocessing & Normalization



Exploratory Data Analysis (EDA)



Feature Engineering (if applicable)



Model Building:

→ CNN

→ Logistic Regression (for comparison)



Model Evaluation (Accuracy, Precision, Recall)



Visualization of Results



Conclusion & Deployment Ready

#### 4. DATA DESCRIPTION:

Dataset: MNIST Handwritten Digits Dataset

- ✓ Source: Available via Keras Datasets or Kaggle
- ✓ Type: Image (grayscale, 28x28 pixels)
- ✓ Records: 70,000 images (60,000 for training, 10,000 for testing)
- ✓ Features: Pixel intensity values (0–255)
- ✓ Static/Dynamic: Static
- ✓ Target Variable: Digit label (0 to 9)

#### 5. DATA PREPROCESSING:

Normalize pixel values to range [0, 1] using  $x/255.0$

- ✓ Reshape images to fit CNN input shape: (28, 28, 1)
- ✓ Convert labels to one-hot encoding using `to_categorical()`

- ✓ No missing values or outliers due to clean dataset
- ✓ Ensure data type consistency (float32 for pixel values)

## 6. EXPLORATORY DATA ANALYSIS(EDA):

Univariate: Count plots of digit distribution (balanced dataset)

- ✓ Image Samples: Visualize sample digits for clarity
- ✓ Pixel Intensity Histogram: Understand grayscale distribution
- ✓ Insights:
  - Dataset is balanced for all digit classes
  - Images are uniform size and quality
  - No missing or corrupt entries

## 7. FEATURE ENGINEERING:

Not applicable for CNN model (feature learning is automatic)

- ✓ For traditional models:
  - Flatten images to 1D (784 features)
  - Apply PCA (optional) for dimensionality reduction

## 8.MODEL BUILDING:

- ✓ Models Implemented:
- ✓ Convolutional Neural Network (CNN):

- Layers: Conv2D → MaxPooling → Dropout → Flatten → Dense
- Activation: ReLU, Softmax
- Optimizer: Adam
- Metrics: Accuracy

✓ Logistic Regression (for baseline comparison):

- Flattened pixel features
- Evaluated with accuracy and confusion matrix

✓ Train-Test Split:

✓ 80:20 on training data (for validation)

✓ Use standard MNIST test set for final evaluation

✓ Metrics Used:

✓ Accuracy, Precision, Recall, F1-Score

## 9. VISUALIZATION OF RESULTS & MODEL INSIGHTS:

- ✓ Confusion Matrix: Shows classification performance across digits
- ✓ Accuracy & Loss Curves: Monitors training vs validation
- ✓ Sample Predictions: Visual comparison of correct and incorrect classifications
- ✓ Feature Importance (Logistic Model): Visualize pixel influence (optional)

## 10. TOOLS AND TECHNOLOGIES USED:

Programming Language: Python

✓ IDE: Jupyter Notebook / Google Colab

✓ Libraries:

- mpy, pandas
- matplotlib, seaborn
- tensorflow.kerasnu
- scikit-learn

## 11. TEAM MEMBERS AND CONTRIBUTIONS:

Name	Contribution
<b>S.Sangdeena</b>	Project Lead, Model Architecture Design (CNN), Training & Optimization
<b>P.Vaishnavi</b>	Data Preprocessing, Data Normalization, One-Hot Encoding
<b>S.Jothiga</b>	Exploratory Data Analysis (EDA), Data Visualization, Insight Generation
<b>R.pradhish</b>	Model Evaluation, Metrics Analysis, Confusion Matrix, ROC Curve
<b>T.Aligesh</b>	Documentation, GitHub Repository Management, Report Formatting and Submission