

## # 🖌️ Handwritten Digit Recognition (MNIST)

This is a \*\*Machine Learning + Deep Learning project\*\* that recognizes handwritten digits (0–9) using a \*\*Convolutional Neural Network (CNN)\*\* trained on the \*\*MNIST dataset\*\*.

The app is built with \*\*Streamlit\*\*, allowing users to:

- 🖌️ Draw digits directly in the browser canvas
  - 📂 Upload single-digit images
  - 📸 Upload images containing multiple handwritten digits
- ...and get instant predictions!

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## ## 🎨 Project Overview

### ### 🎯 Objective

To identify handwritten digits from user input using a CNN model trained on the MNIST dataset.

### ### 🛠️ Technologies Used

- \*\*Python\*\*
- \*\*TensorFlow / Keras\*\*
- \*\*Streamlit\*\*
- \*\*Pillow (PIL)\*\*
- \*\*NumPy & Pandas\*\*
- \*\*streamlit-drawable-canvas\*\*

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## ## 🧠 How It Works

### 1. \*\*Model Training\*\*

- A CNN is trained on MNIST dataset (60,000 training, 10,000 testing samples).
- Model achieves around \*\*98–99% accuracy\*\*.
- The trained model is saved as `mnist\_cnn.h5`.

## 2. \*\*Web App\*\*

- Built using Streamlit.
- Loads the trained model.
- Supports three input modes:
  - Draw a digit
  - Upload a single digit image
  - Upload an image with multiple digits
- Automatically preprocesses input to match MNIST format (28×28 grayscale).

## 3. \*\*Prediction\*\*

- The model outputs probabilities for digits 0–9.
- The highest probability determines the predicted digit.

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## ## 🌟 Features

Feature	Description
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✎ Draw Digit	Draw any digit 0–9 directly on screen
📸 Upload Image	Upload a single digit photo for recognition
1234 Multi-digit Support	Upload an image containing multiple digits (like “2025”)
📈 Probabilities	See confidence scores for each digit
🚧 Real-time Processing	Instant predictions through Streamlit interface

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## ## 🚀 How to Run Locally

### ### 1 Clone the repository

```
```bash
git clone https://github.com/<your-username>/mnist-digit-recognition.git
cd mnist-digit-recognition
```

### ### 2 Create a virtual environment

```
```bash
python -m venv venv
venv\Scripts\activate
```

```
### 3 Install dependencies
```

```
```bash
pip install -r requirements.txt
```

```
### 4 Run the Streamlit app
```

```
```bash
streamlit run app.py
```

## ✳️ Project Structure

```
mnist_digit_recognition/
|
├── app.py          # Streamlit web application
├── mnist_train.py  # CNN training script
├── mnist_cnn.h5    # Trained CNN model file
├── requirements.txt # Required dependencies
├── README.md       # Project documentation
└── .gitignore       # Ignore unnecessary files
```

## 📦 Dependencies

```
streamlit
tensorflow
Pillow
numpy
pandas
streamlit-drawable-canvas
```

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