Handwritten Character Recognition

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Task-3(CodeAlpha)

I. Introduction

This project aimed to design, train, and evaluate a deep learning model capable of recognizing handwritten digits (0-9). The model was first trained using the MNIST dataset, a widely used benchmark for handwritten digit recognition, and subsequently tested on a custom dataset of handwritten digits created specifically for this assignment. This report presents the detailed methodology, results, and insights gained from the assignment. Emphasis is placed on analyzing the custom dataset performance, where the model achieved 80% accuracy, with all digits correctly identified except for 1 and 8, which were misclassified.

Dataset Description

1. Training Dataset:
    - Source: MNIST Dataset (Modified National Institute of Standards and Technology).
    - Composition:
        - Training set: 60,000 grayscale images of digits (0-9).
        - Test set: 10,000 grayscale images of digits (0-9).
    - Image Details:
        - Size: 28×28 pixels.
        - Range of pixel values: 0 to 255 (normalized to [0, 1]).
        - Format: White digits on a black background.
2. Custom Testing Dataset:
    - Composition: 10 images of handwritten digits (0-9), manually written on paper, scanned, and stored as individual images.
    - Image Details:
        - Size: 28×28 pixels (after preprocessing).
        - Format: Grayscale, white digits on a black background, matching MNIST style.
    - Labels: File names (e.g., 0.png, 1.png) served as the ground truth labels.

II. Model Architecture

The 3-layer deep neural network was designed as follows:

1. Input Layer:
    - Purpose: Flatten 28×28 images into 1D arrays of 784 pixels.
    - Implementation: Explicit input layer using Keras Input().
2. Hidden Layers:
    - Layer 1:
        - 128 neurons with ReLU (Rectified Linear Unit) activation.
        - ReLU helps introduce non-linearity and mitigates the vanishing gradient problem.
    - Layer 2:
        - 64 neurons with ReLU activation.
3. Output Layer:
    - 10 neurons corresponding to the 10 digit classes (0-9).
4. Model Compilation:
    - Metrics: Accuracy to evaluate model performance.

III. Training Process

1. Data Preprocessing:
    - Pixel values were normalized to the range [0, 1].
    - Images were reshaped to include the channel dimension: (samples, 28, 28, 1).
2. Training Parameters:
    - Epochs: 10.
    - Batch Size: 32.
3. Performance on MNIST:
    - Training Accuracy: 97.88%.

IV. Testing on Custom Dataset

The trained model was tested on a custom dataset of 10 handwritten digit images (0-9). The following steps were taken:

1. Preprocessing:
    - Images were converted to grayscale.
    - Resized to 28×28 pixels to match the MNIST format.
    - Pixel values were normalized to [0, 1].

    - Colors were inverted to align with MNIST's white-digit-on-black-background format.
2. Results:
    - Overall Accuracy: 80%.
    - Correct Predictions: 8 out of 10 digits (0, 2, 3, 4, 5, 6, 7, 9) were correctly classified.
    - Misclassified Digits:
        - Digit 1: Misclassified as 2.
        - Digit 8: Misclassified as 3.
    - Misclassification Analysis:
        - Digit 1 Misclassification: Likely due to the unclear format of writing.
        - Digit 8 Misclassification: The handwritten "8" may have irregular loops or thicknesses not seen in MNIST, leading to confusion with the shape of "3."

V. Conclusion

The project successfully demonstrated the potential of a 3-layer deep neural network in recognizing handwritten digits. The model achieved:

- 97.88% accuracy on the MNIST test set.
- 80% accuracy on the custom handwritten dataset, with 8 out of 10 digits correctly identified.

While the results are promising, the misclassifications underscore the need for improved generalization through enhanced data augmentation and advanced architectures.