Deep Learning
Assignment 3
Comparative Analysis of Fully Connected ANN and CNN for MNIST Digit Classification

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Abstract

This report presents a comparative analysis of two neural network architectures, namely a Fully Connected Artificial Neural Network (ANN) and a Convolutional Neural Network (CNN), for the task of MNIST digit classification. The models are evaluated based on accuracy, number of parameters, and computational efficiency. The results indicate that CNN outperforms ANN in terms of accuracy and efficiency due to its ability to exploit spatial hierarchies in images.

1 Introduction

Handwritten digit classification is a fundamental task in image processing and deep learning. The MNIST dataset, which consists of 70,000 grayscale images of handwritten digits (0-9), is a benchmark for evaluating machine learning models. This report compares the performance of ANN and CNN in classifying MNIST digits.

2 Methodology

2.1 Dataset

The MNIST dataset was used, with 60,000 training samples and 10,000 test samples. Each image is of size 28x28 pixels.

2.2 Model Architectures

Fully Connected ANN:

- Input layer: 784 neurons (flattened 28x28 image)
- Hidden layers: 128 neurons (ReLU), 64 neurons (ReLU)
- Output layer: 10 neurons (softmax)
- Total parameters: 109,386

CNN:

- Conv2D (32 filters, 3x3, ReLU) + MaxPooling(2x2)
- Conv2D (64 filters, 3x3, ReLU) + MaxPooling(2x2)
- Flatten layer
- Dense layer: 128 neurons (ReLU)
- Output layer: 10 neurons (softmax)
- Total parameters: 225,034

2.3 Training Details

Both models were trained using the Adam optimizer, with a sparse categorical cross-entropy loss function. The models were trained for 10 epochs with a batch size of 32.

3 Results

Model	Test Accuracy	Number of Parameters
ANN	97.82%	109,386
CNN	99.12%	225,034

Table 1: Comparison of ANN and CNN performance on MNIST.

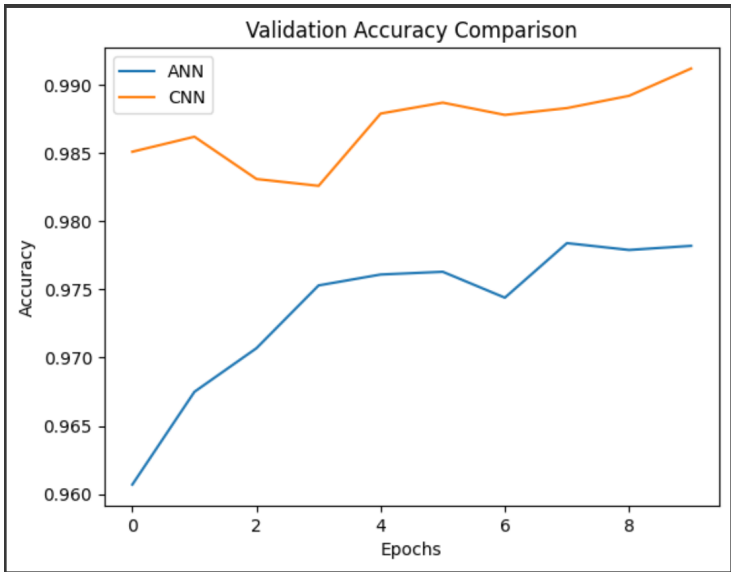

Figure 1: Validation accuracy comparison between ANN and CNN.

4 Discussion

The results demonstrate that the CNN significantly outperforms the ANN in terms of accuracy (99.12% vs. 97.82%). This improvement is attributed to CNN's ability to capture spatial hierarchies in images through convolutional layers, making it more efficient for image classification tasks.

Although the CNN has a higher number of parameters (225,034 vs. 109,386), its superior performance justifies the additional complexity. Moreover, CNNs require fewer fully connected parameters, reducing overfitting compared to ANNs.

5 Conclusion

This study confirms that CNNs are better suited for image classification tasks like MNIST digit recognition compared to traditional ANNs. Future work may involve testing more complex architectures or applying techniques such as data augmentation to further improve performance.