Dept Scientific Computing, Modelling & Simulation, SPPU

Title: The Performance Comparison of Artificial Neural Network (ANN) and Convolutional Neural Network (CNN) on MNIST Image Data

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INTRODUCTION:

Neural networks have become the cornerstone of modern artificial intelligence, especially in the fields of computer vision and pattern recognition. Artificial Neural Networks (ANNs) are fundamental deep learning architectures that use interconnected neurons to process inputs and generate predictions. However, ANNs treat images as one-dimensional vectors, losing important spatial information. Convolutional Neural Networks (CNNs) overcome this limitation by using convolutional filters to extract local spatial features, making them highly effective for image-based tasks. This project aims to understand how these two architectures differ in their ability to classify images and generalize to unseen data

PROBLEM STATEMENT:

Objective: To compare the performance of ANN and CNN in classifying handwritten digits from the MNIST dataset.

Input: 28×28 grayscale images of handwritten digits (0–9).
Output: Predicted class label (digit 0–9).

The comparison will be based on model accuracy, training time, and computational efficiency

MOTIVATION:

Understanding the comparative strengths of ANN and CNN helps in selecting the right model architecture for specific applications. While ANNs are simpler and computationally cheaper, CNNs excel at learning spatial hierarchies directly from pixel data. This comparison enhances the understanding of deep learning fundamentals and the importance of architecture choice in performance outcomes.

LITERATURE SURVEY:

LeCun et al. (1998) introduced the LeNet architecture for digit recognition, laying the foundation for modern CNNs. Their work demonstrated how convolutional layers could automatically extract meaningful image features. Krizhevsky et al. (2012) proposed AlexNet, which revolutionized image recognition by achieving breakthrough performance on the ImageNet dataset. Subsequent models such as VGGNet, ResNet, and Inception further improved CNN capabilities, emphasizing depth and modular design. These works collectively highlight the evolution of neural network architectures from fully connected ANNs to highly efficient CNNs

PROPOSED METHODOLOGY:

The proposed study follows the following steps:

1. Data Collection: Use the MNIST dataset consisting of 70,000 grayscale images of digits (0–9).

2. Data Preprocessing: Normalize image pixel values between 0 and 1. Reshape data for ANN (flattened vector) and CNN (2D image format).

3. Model Development:
   - ANN: Input → Dense layers → Output layer
   - CNN: Convolution → Pooling → Dense layers → Output layer

4. Training Setup: Use Adam optimizer, categorical cross-entropy loss, batch size of 32, and 10 epochs.

5. Evaluation Metrics: Accuracy, Precision, Recall, F1-score, and training time.

6. Comparison: Analyse both quantitative (accuracy, loss curves) and qualitative results (misclassified images).

Dataset and Evaluation:

The MNIST dataset consists of 60,000 training and 10,000 testing images of handwritten digits (0–9). Each image is 28×28 pixels in grayscale format. Data is normalized and reshaped according to the input requirements of ANN and CNN models. Evaluation is performed using the following metrics:
- Accuracy
- Precision, Recall, and F1-score
- Training time comparison
- Confusion matrix for error analysis

References:

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