# Performance Comparison of ANN and CNN on MNIST Dataset

Project Report

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Course: Deep Learning Project

## 1. Introduction

Artificial Neural Networks (ANNs) and Convolutional Neural Networks (CNNs) are two fundamental deep learning architectures used for classification tasks. ANNs process flattened data and work well with simple patterns, while CNNs are designed to capture spatial relationships in images. This project focuses on comparing their performance on the MNIST dataset, which consists of handwritten digits (0–9).

## 2. Problem Statement

The aim of this project is to evaluate and compare the performance of ANN and CNN in classifying handwritten digits from the MNIST dataset.  
   
Input: 28×28 grayscale images of digits (0–9)  
Output: Predicted digit (0–9)

## 3. Motivation

Understanding the differences between ANN and CNN helps in choosing the right architecture for specific types of data. The motivation for this project is to analyze why CNNs perform better for image data and demonstrate their superiority through experimental results.

## 4. Goal

To compare ANN and CNN models on MNIST dataset in terms of accuracy, loss, and training time, and to highlight the impact of architectural design on model performance.

## 5. Literature Survey

- LeCun et al. (1998): Introduced the LeNet architecture for digit recognition, which became the foundation of modern CNNs.  
- Krizhevsky et al. (2012): Proposed AlexNet, which showed the power of CNNs in large-scale image recognition.  
- Recent studies: CNNs achieve over 99% accuracy on MNIST, while ANNs typically reach around 97–98%.

## 6. Methodology

Steps followed in the project:  
1. Dataset collection: MNIST dataset from Keras.  
2. Data preprocessing: Normalization and reshaping for ANN and CNN.  
3. Model design:  
 - ANN: Input → Hidden (Dense) Layers → Output  
 - CNN: Conv2D → MaxPooling → Flatten → Dense → Output  
4. Model training: Same optimizer, epochs, and loss function for both.  
5. Model evaluation: Compare test accuracy and training time.

## 7. Tentative Dataset

Dataset: MNIST (Modified National Institute of Standards and Technology)  
- 60,000 training images  
- 10,000 testing images  
- Image size: 28×28 grayscale

## 8. Evaluation Methods

The models were evaluated using:  
- Accuracy  
- Precision, Recall, and F1-score  
- Training time  
- Loss curves comparison

## 9. Error Analysis

Quantitative Analysis:  
- Confusion matrix to identify misclassified digits.  
- Calculation of misclassification rate.  
  
Qualitative Analysis:  
- Visualization of sample misclassified images.  
- Observing cases where ANN failed but CNN succeeded.

## 10. Conclusion

The CNN model achieved higher accuracy and lower loss compared to the ANN model on the MNIST dataset. The convolutional architecture effectively captured spatial hierarchies, making it better suited for image classification tasks. This study reinforces that CNNs outperform traditional ANNs when dealing with image-based data.