Lab04 ITAI 2376 - Convolutional Neural Networks (CNN) with MNIST Dataset

Part 1: Technical Implementation

Introduction

This lab focuses on implementing a Convolutional Neural Network (CNN) using the MNIST dataset. The MNIST dataset consists of handwritten digits, making it a fundamental benchmark for image classification tasks.

Steps to Complete the Lab

1. **Download and Open the Notebook**
   - Access the provided notebook from Module 04.
   - Upload the notebook to Google Colab.
2. **Understanding the Dataset**
   - The MNIST dataset contains 60,000 training images and 10,000 testing images of digits (0-9).
   - Each image is 28x28 pixels in grayscale.
3. **Building the CNN Model**
   - **Layers Used:**
     - Convolutional layers for feature extraction.
     - Max-pooling layers for down-sampling.
     - Fully connected layers for classification.
   - **Activation Functions:**
     - ReLU for non-linearity.

        - Softmax for final classification.

4. **Training and Evaluating the Model**
    - Compile the model using an appropriate loss function (categorical cross-entropy).
    - Train the model with multiple epochs and batch sizes.
    - Evaluate performance using accuracy metrics.
5. **Visualizing the Results**
    - Display training accuracy and loss curves.
    - Visualize sample predictions.
6. **Saving and Exporting the Notebook**
    - Ensure all cells execute without errors.
    - Save the completed notebook as a PDF (File → Print → Save as PDF).

Part 2: Reflective Journal

Learning Insights

- The lab provided hands-on experience in constructing CNNs from scratch.
- Learned about feature extraction using convolutional layers.
- Understood how pooling layers help reduce computational complexity while retaining important features.
- Observed the impact of different hyperparameters on model performance.
- Reinforced previous knowledge of neural networks by applying it to real-world image classification.
- Surprised by the ability of a simple CNN to achieve high accuracy on MNIST.

Challenges and Growth

- **Challenges Faced:**
    - Understanding the dimensional transformations across layers.
    - Tuning hyperparameters like learning rate and number of epochs.
    - Managing runtime errors in Colab due to memory constraints.
- **Overcoming Challenges:**
    - Referencing documentation and online resources for troubleshooting.
    - Experimenting with different architectures and observing their impact.
    - Using visualization tools to debug misclassified images.

Personal Development

- Gained a deeper understanding of deep learning and CNNs.
- Improved confidence in implementing models from scratch.
- Interested in exploring more complex architectures like ResNets and GANs.
- Recognized the importance of computational efficiency in real-world applications.

Conclusion This lab reinforced the core principles of CNNs and their application to image classification. The hands-on experience provided valuable insights into the structure and behavior of deep learning models.