Deep Learning Assignment Report

1. Introduction

The creation, optimization, and assessment of a neural network model for structured data classification using the Forest CoverType dataset are described in this report. Applying deep learning techniques and contrasting the outcomes with a traditional ensemble model (Random Forest) is the aim.

2. Neural Network Architecture

Two hidden layers with 256 and 128 units, respectively; LeakyReLU activation to prevent dying neurons; Batch Normalization for quicker and more stable training; Dropout layers (0.4 and 0.3) to lessen overfitting; and L2 regularization on dense layers to penalize large weights were the design choices used to implement a multi-layer perceptron (MLP) model.

3. Regularization and Optimization

The following strategies were employed to enhance training stability and generalization: Dropout (0.3–0.4) to prevent co-adaptation of neurons; L2 regularization to lower model complexity; Adam optimizer for adaptive learning; ReduceLROnPlateau callback to lower learning rate on validation loss plateau; and EarlyStopping to end training early when no improvement was seen.

4. Evaluation Metrics

Considering the dataset's class imbalance, the following metrics were calculated in addition to accuracy: precision (weighted and macro), recall (weighted and macro), F1-score (weighted and macro), and confusion matrix (for a more thorough class-level analysis).

5. Results Summary

The MLP produced competitive results, but because of its natural affinity for tabular data, the Random Forest model marginally outperformed it on some metrics. The regularization techniques used resulted in training curves showing good convergence with little overfitting.

6. Comparison with Ensemble Methods

For comparison, the baseline ensemble model was Random Forest. On structured datasets, it demonstrated strong generalization without requiring a lot of tuning, confirming its potency. In spite of the MLP's performance, Random Forest offered more stable class predictions and a better macro F1-score.

7. Reflection

Because tree-based models, such as Random Forest, are more resilient to feature scale and data distribution, require less preprocessing and hyperparameter tuning, and naturally capture feature interactions, they frequently perform better on tabular data than MLPs. In contrast, MLPs need careful architecture and regularization techniques to reach comparable performance levels.

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