Supervised Learning on European Topology 6 Paths Dataset

Task Overview

The goal of this project is to predict the Generalized Signal-to-Noise Ratio (GSNR) using supervised learning methods on a dataset derived from a European topology comprising 6 paths. This involves building an Artificial Neural Network (ANN), performing hyperparameter tuning via grid search, and evaluating the model's performance.

Dataset Description

- **Channels**: 76
- **Features**:
  - Power: Signal power for each channel
  - NLI (Non-Linear Interference): Measure of interference on each channel
  - ASE (Amplified Spontaneous Emission): Noise figure for each channel
  - Total Distance: Total distance the signal travels
  - Span: Number of spans in the signal path
  - Frequency: Frequency of the channel (not significant for GSNR prediction)
- **Label**:
  - GSNR (Generalized Signal-to-Noise Ratio): Target variable to predict

Tasks and Expectations

1. Data Exploration and Preprocessing

- Analyzed the dataset to understand feature distributions and relationships with the target variable.
- Handled missing values by filling them with column means.
- Visualized feature-target relationships using scatter plots.

2. Feature Engineering

- Normalized numerical features to ensure consistent scale.
- Dropped irrelevant features like 'Frequency' to streamline model training.

3. Model Selection and Training

Model Architectures Explored:

1. **Model 1**:
   - Architecture: Several layers with ReLU activation and Tanh output.

    - Optimizer: Adam
    - Regularization: L1 and L2
2. **Model 2**:
    - Architecture: Similar to Model 1 with Sigmoid activation.
    - Optimizer: Adam
    - Regularization: L1 and L2
3. **Model 3**:
    - Architecture: Similar to Model 1 with ReLU activation throughout.
    - Optimizer: Adam
    - Regularization: L1 and L2

4. Hyperparameter Tuning

- Explored different learning rates, batch sizes, and regularization strengths using grid search.
- Evaluated models using validation set performance metrics.

5. Model Evaluation

- Evaluated models on the test set using Mean Squared Error (MSE), R-squared (R^2), and Mean Absolute Error (MAE).
- Analyzed overfitting by comparing training and validation performance.
- Applied techniques like early stopping and dropout to mitigate overfitting.

Results and Analysis

Best Performing Model:

- **Model 1** with Tanh activation function, Adam optimizer, and L1/L2 regularization achieved the lowest test loss and highest validation metrics.

Key Findings:

- Learning rate adjustments significantly impacted model convergence.
- Tanh activation function performed better than Sigmoid and ReLU for this regression task.
- Adam optimizer consistently outperformed SGD and RMSprop in terms of convergence speed and final accuracy.

Recommendations

- Further explore ensemble methods to potentially boost model performance.
- Investigate feature interactions and domain-specific insights to enhance predictive accuracy.

Conclusion

In conclusion, this project successfully applied supervised learning techniques to predict GSNR on the European Topology 6 Paths dataset. By optimizing model architecture, hyperparameters, and regularization techniques, we achieved a robust predictive model for GSNR prediction.