**Report on LTC Model Performance for EEG Signal Classification**

**1. Introduction** The purpose of this report is to analyze the performance of the LTC (Liquid Time-Constant) model on EEG signal classification. EEG signals are essential for various applications, including brain-computer interfaces, medical diagnostics, and cognitive state analysis. This study aims to evaluate the model’s classification accuracy across different EEG channels based on extracted features.

**2. Features Extracted** The model utilizes 15 extracted features from EEG signals, including:

* Statistical Features: Mean, Standard Deviation, Skewness, Kurtosis, Maximum, Minimum
* Band Power Features: Alpha, Beta, Theta, Gamma, Alpha/Beta Ratio
* Complexity Features: Mobility, Complexity, Spectral Entropy
* Peak Count Feature: Length of peak count array

**3. Model Performance Analysis** The LTC model was applied to EEG signals across 22 channels (0 to 21). Below is a summary of its classification performance based on accuracy, precision, recall, and F1-score:

| **Channel** | **Accuracy (%)** | **Precision** | **Recall** | **F1-Score** | **Best Performing Class** | **Worst Performing Class** |
| --- | --- | --- | --- | --- | --- | --- |
| 0 | 23 | 0.25 | 0.25 | 0.41 | 769 | 771 |
| 1 | 22 | 0.47 | 0.26 | 0.19 | 769 | 770 |
| 2 | 29 | 0.43 | 0.29 | 0.28 | 769 | 772 |
| 3 | 22 | 0.36 | 0.21 | 0.34 | 771 | 770, 1023 |
| 4 | 26 | 0.46 | 0.23 | 0.21 | 770 | 1023 |
| 5 | 29 | 0.44 | 0.28 | 0.30 | 770 | 1023 |
| 6 | 11 | 0.27 | 0.13 | 0.47 | 769 | 1023, 772 |
| 7 | 23 | 0.42 | 0.20 | 0.19 | 770 | 1023 |
| 8 | 18 | 0.32 | 0.16 | 0.34 | 771 | 1023 |
| 9 | 32 | 0.54 | 0.29 | 0.26 | 769 | 1023 |
| 10 | 21 | 0.57 | 0.25 | 0.21 | 769 | 772 |
| 11 | 34 | 0.48 | 0.33 | 0.34 | 771, 772 | 1023 |
| 12 | 31 | 0.45 | 0.26 | 0.25 | 771, 772 | 1023 |
| 13 | 18 | 0.27 | 0.18 | 0.50 | 770 | 1023, 771, 772 |
| 14 | 25 | 0.40 | 0.24 | 0.20 | 769 | 1023 |
| 15 | 18 | 0.52 | 0.18 | 0.12 | 770 | 1023, 771, 772 |
| 16 | 23 | 0.55 | 0.21 | 0.17 | 771 | 1023, 772 |
| 17 | 28 | 0.41 | 0.22 | 0.20 | 770, 771 | 1023 |
| 18 | 22 | 0.43 | 0.21 | 0.17 | 769 | 1023 |
| 19 | 23 | 0.39 | 0.22 | 0.16 | 771 | 1023, 770 |
| 20 | 16 | 0.34 | 0.15 | 0.12 | 770 | 1023 |
| 21 | 21 | 0.39 | 0.20 | 0.16 | 769 | 1023 |

**4. Challenges and Observations**

* The model struggles with certain classes, especially those with fewer instances in the dataset.
* Precision and recall scores fluctuate significantly across different channels.
* Some channels show improvement in recall but poor precision, indicating misclassifications.
* Feature selection may require refinement to enhance classification performance.

**5. Recommendations for Improvement** To enhance the LTC model’s performance on EEG classification:

1. **Feature Engineering Enhancements**:
   * Incorporate additional EEG features such as Fractal Dimension and Hjorth Parameters.
   * Improve spectral feature extraction techniques.
2. **Model Optimization**:
   * Utilize deeper architectures with fine-tuned hyperparameters.
   * Experiment with different activation functions suited for EEG data.
3. **Data Augmentation & Preprocessing**:
   * Balance the dataset for underrepresented classes.
   * Apply normalization techniques to improve stability.

**6. Conclusion** The LTC model demonstrates the potential for EEG classification but requires further optimization. Future improvements in feature engineering, model tuning, and data preprocessing could significantly enhance classification accuracy and robustness.