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

Channel	Accuracy (%)	Precision	Recall	F1-Score	Best Performing Class	Worst Performing Class
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.