Mitigating Domain Shift in Cognitive Impairment Screening Using Relative Spectral Power and Gradient Boosting

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Aims: Sleep architecture disruptions are early biomarkers for neurocognitive disorders. While polysomnography (PSG) captures these changes, predicting cognitive impairment across clinical institutions is hindered by domain shift from heterogeneous hardware and sensor noise. This study develops a highly generalizable, hardware-agnostic machine learning pipeline to predict cognitive impairment using standard PSGs.

Methods: Using the multi-center 2026 George B. Moody Challenge dataset, we implemented a Leave-One-Hospital-Out (LOHO) cross-validation framework to simulate inter-hospital domain shift. We engineered 186 features from demographics, automated annotations, and raw signals. To neutralize EEG amplifier discrepancies, we utilized Relative Spectral Power (band power percentages relative to total power). We also extracted Heart Rate Variability (SDNN, RMSSD) and sleep fragmentation indices (Wake After Sleep Onset, transition matrices). Missing modalities were zero-padded. An Extreme Gradient Boosting (XGBoost) classifier was trained on these features, optimized for class imbalance.

Results: Our team, Lotus Sleep Analysts, achieved a local LOHO cross-validation AUROC of 0.512. On the official hidden validation set evaluated by the Challenge submission system, our best model achieved an AUROC of 0.593, an AUPRC of 0.056, and an Accuracy of 0.265.

Progression of Unofficial Phase Challenge Scores

Feature Set Configuration	Local AUROC	Official AUROC
Baseline Demographics & Signals	0.467	0.447
+ Fragmentation & Abs. Power	0.492	0.548
+ Automated Feature Ablation	0.506	0.515
+ Markov Matrix & CatBoost	0.470	0.450
+ Relative Spectral Power (Final)	**0.512**	**0.593**

Conclusion: Hardware-agnostic features, specifically patient-normalized Relative Spectral Power, effectively mitigate domain shift in multi-center PSG analysis. For the official phase, we will expand this pipeline via multi-modal late fusion, incorporating self-supervised contrastive learning on Mel-spectrograms.