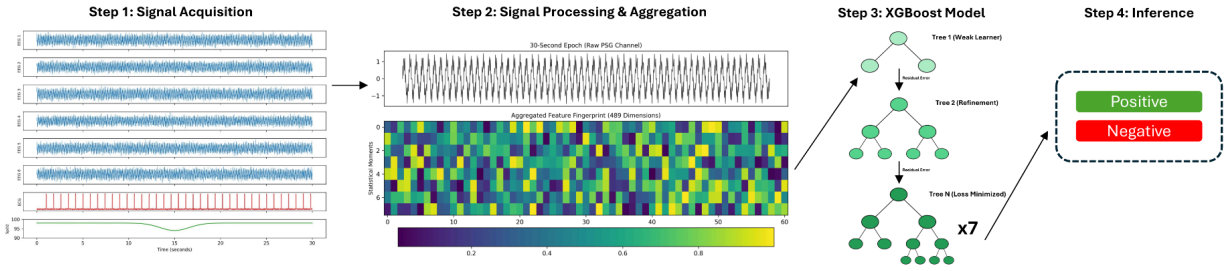
Provisory Title: Predicting Early Cognitive Impairment with Polysomnographic Epoch-Level Features

Abstract:
Disrupted sleep, including reduced slow-wave activity and breathing irregularities, can reveal early neurological changes via polysomnography (PSG). Early detection of neurodegenerative disease is challenging because current diagnostic methods rely on symptomatic presentation, and PSG is used for sleep disorder diagnosis rather than neurological risk assessment. Our approach uses epoch-level PSG biomarkers to detect early signs of neurodegenerative disorders, including mild cognitive impairment, Alzheimer's disease, dementia, and Primary Progressive Aphasia, years before diagnosis.

We analyzed PSG recordings from the Human Sleep Project database collected across five U.S. academic medical centers. Recordings included six EEG channels, bilateral EOG, chin EMG, respiratory effort, nasal airflow, SpO2, and a single-lead ECG, all sampled at 200 Hz in EDF format. CAISR annotations provided 30-second sleep stages, arousals, and respiratory events, while the outcome was whether patients received a cognitive impairment diagnosis within 3–7 years. For each 30-second epoch, we extracted spectral band power and Hjorth parameters, aggregated features into patient-level summary statistics (mean, standard deviation, and 5th/25th/75th/95th percentiles). 61 features were extracted per 30-second epoch and aggregated into 489 temporal statistics. These features were classified by an XGBoost ensemble, with hyperparameters tuned via a 100-trial Optuna Bayesian search and 5-fold cross-validation.



Internal cross-validation yielded a mean AUROC of 0.636 ± 0.0058 across a cohort of 780 patients (70.4 ± 8.3 years old), consisting of 60.4% male (n=471) and 39.6% female (n=309). The PhysioNet holdout test set returned an AUROC of 0.671 (18/243 Ranking), a 40.38% improvement over the baseline RandomForest model. These findings suggest a gradient-boosted model trained on PSG features can effectively classify cognitive impairment risk. Future work includes pre-training on an external PSG dataset and leveraging a neural teacher model for feature distillation to improve downstream classifier performance.