Integrating Sleep Macroarchitecture and Multi-Modal PSG Features for Cognitive Impairment Prediction

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Aim: Cognitive impairment (CI) represents a growing public health burden, and early identification before clinical manifestation remains a key challenge. Polysomnography (PSG) provides a multimodal assessment of sleep, capturing neurological, cardiovascular, respiratory, and motor signals, possibly reflecting early polypathic dysfunction associated with or preceding CI diagnosis. To this aim, the MeDSP team proposes a multi-domain automatic framework for predicting future CI from overnight PSG recordings.

Methods: 662 PSG recordings from the Human Sleep Project were included in the training set. Over 400 features were extracted, describing sleep architecture, EEG spectral content across sleep stages, oxygen saturation, respiratory events, arousals, limb movements, hypnogram complexity and demographic variables. By minimum redundancy maximum relevance algorithm, 43 features were selected, including age as a clinically relevant predictor. On them, feature imputation was performed whenever necessary by group-wise median estimates, followed by Z-score normalization. Classification was performed using an AdaBoost decision tree classifier (21 leaf nodes, 30 cycles, learning rate 0.1). Model performance was assessed either via 10-time 10-fold stratified cross-validation on the training set, in terms of Area Under the Receiver Operating Characteristic curve (AUROC), accuracy (ACC), sensitivity (TPR), and specificity (TNR), and on the hidden validation set by AUROC.

Results: On the training set, the model achieved an AUROC of 0.81 ± 0.05, accuracy of 0.76 ± 0.06, TPR of 0.79 ± 0.07, and TNR of 0.74 ± 0.08. However, performance on the hidden validation set led to an AUROC of 0.51.

Conclusions: Although the model achieved promising performance on the training set, the low validation performance suggests limited generalizability. Future work will incorporate physiologically plausible biomarkers of CI, including sleep related EEG signatures, to improve model robustness.