EEG-Based Dementia Assessment Using Graph Attention Networks for Disease Severity Classification and MoCA Prediction

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Abstract

Dementia is characterized by progressive and irreversible neurodegeneration, resulting in cognitive decline and loss of functional independence. Conventional assessment approaches, including neuroimaging modalities such as MRI, CT, and PET, as well as cognitive screening tools such as the Montreal Cognitive Assessment (MoCA), are often limited by cost, accessibility, scalability, and dependence on examiner-administered testing. This study proposes an objective EEG-based framework for dementia severity classification and continuous cognitive score prediction using a modified Graph Attention Network (GATv2). Resting-state EEG recordings from 102 participants spanning four clinical stages—normal cognition (N = 32), mild cognitive impairment (MCI, N = 39), moderate dementia (N = 22), and severe dementia (N = 9)—were analyzed. Multi-band functional connectivity was quantified using coherence and phase-locking value (PLV) across five frequency bands, and the resulting connectivity matrices were represented as graphs in which EEG channels served as nodes and functional connections as weighted edges. To mitigate class imbalance and improve model robustness, a two-stage pre-training and fine-tuning strategy was employed. Under 10-fold cross-validation, the proposed GATv2 model achieved an overall classification accuracy of 83% and a weighted F1-score of 0.83, outperforming CNN and CNN-Conformer baselines. For continuous cognitive assessment, the model predicted MoCA scores with a mean absolute error of 3.37 points and demonstrated a moderate correlation with measured scores (Pearson's $r = 0.54$, $p < 0.01$). Functional connectivity analysis further revealed increased connectivity in the MCI stage, potentially reflecting compensatory neural mechanisms, followed by progressive disruption of frontal–parietal network organization with increasing dementia severity. These results demonstrate that graph-based modeling of multi-band resting-state EEG connectivity can provide a practical and objective framework for dementia staging and continuous cognitive function assessment.

Keywords

Cognitive assessment, dementia, electroencephalography, functional connectivity, graph attention network.