CogSleep-Net: A Cognitive-Inspired Hierarchical Framework for Automatic Sleep Staging

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Abstract

Sleep staging is a fundamental component of clinical sleep assessment and neurological screening. While recent deep learning methods have improved automatic sleep staging, most approaches treat it as a static sequence classification problem and overlook key cognitive mechanisms underlying expert scoring, including prior-guided perception, hierarchical abstraction, and contextual memory integration. To address this gap, we propose CogSleep-Net, a cognitively inspired framework that models sleep staging as a dynamic reasoning process driven by coordinated perception, abstraction, and memory. The model integrates prior-guided dual-domain perception to emphasize physiologically salient patterns, hierarchical abstraction to disentangle micro-level waveforms from macro sleep dynamics, and a novel gated state-space memory mechanism that combines short-term evidence with long-term contextual information. CogSleep-Net is evaluated on two public benchmarks (Sleep-EDF-78 and ISRUC-S1) and a self-collected high-density PSG dataset. It achieves 87.25% accuracy and 86.59% macro-F1 on Sleep-EDF-78, with consistent gains across datasets, demonstrating strong robustness and clinical applicability.

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