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Research Article

Real-Time Sleep Stage Detection System for Suspected Obstructive Sleep Apnea Subject using Deep Learning Interpretability-based Feature Selection

Atanu Sett[1], Bijoy Laxmi Koley[2*]

[1]Aditya Infrastructure, Kolkata, West Bengal, India. atanukumarsett1985@gmail.com
[2]Electrical Engineering Department, Dr. B. C. Roy Engineering College, Durgapur, WB, India, bijoylaxmi.koley@bcrec.ac.in

Abstract:
Purpose This study aims to develop an efficient and interpretable sleep stage classification system for individuals with suspected obstructive sleep apnea (OSA). By combining deep learning and feature selection, a lightweight Convolutional Neural Network (CNN) is proposed to classify sleep stages while minimizing computational complexity and enhancing model interpretability.
Methods: A single-layer CNN architecture is optimized using Locally Interpretable Model-Agnostic Explanations (LIME), a feature selection technique that identifies the most discriminative features. The study compares LIME with the traditional Support Vector Machine Recursive Feature Elimination (SVM-RFE) approach. The model is trained and tested on two datasets: an expanded clinical dataset and the MIT-BIH PSG database, assessing its robustness and generalizability.
Results indicate that LIME improves interpretability and computational efficiency without compromising classification accuracy. The CNN achieved an accuracy of 96.9% with all features and maintained comparable performance (~94%-96%) using only LIME-selected features. Additionally, inter-database testing confirmed the model's robustness, demonstrating consistent performance across diverse datasets.
Conclusion The study successfully demonstrates that combining deep learning interpretability techniques like LIME with feature selection can optimize the performance and efficiency of CNN-based sleep stage classifiers for suspected OSA subjects. The simplified CNN architecture, combined with effective feature selection, makes the model both computationally light and interpretable, which is crucial for real-time clinical use. The results highlight LIME's superiority over SVM-RFE in feature selection, providing a more interpretable and practical approach for OSA diagnosis and management.

Key words: Deep learning interpretation, EEG, feature selection, Real-time system, sleep- apnea, sleep stage

Authors for correspondence: E-mail Id: bijoylaxmi.koley@bcrec.ac.in

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1. Introduction

Sleep, a fundamental circadian rhythm, orchestrates a symphony of vital functions within our bodies, navigating us through a sequence of restorative stages. Yet, the shadow of sleep deprivation looms ominously, casting a pall over our well-being with escalating risks of hypertension, cardiovascular ailments, and obesity. One of the most common sleep disorders is obstructive sleep apnea (OSA) which has been estimated to affect up to 38% of the general population [1].