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SIESTA: A Spectral-Temporal Unified Framework for Robust Cross-Subject EEG Analysis

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Abstract

Electroencephalography (EEG) provides critical insights into brain activity, yet its inherent variability and nonstationary nature pose significant challenges for computational analysis, particularly in cross-subject generalization tasks. We present SIESTA (Spectral Invariant EEG-based Semi-causal Transform Architecture), a novel EEG foundation model that addresses these challenges through three key innovations: (1) VQGAN-based spectral tokenization capturing wavelet representation of EEG; (2) a dual-stream Transformer architecture pre-trained using a semi-causal generative modeling approach; and (3) Contrastive Invariant Fine-Tuning (CIFT), a label-free domain adaptation strategy that aligns feature distributions across subjects by integrating spectral-temporal dynamics. Pre-trained on over 32,900 hours of diverse EEG data, SIESTA achieves state-of-the-art performance in epilepsy monitoring, improves F1-score by $12.4

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