INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
PhD-17 SHORT ABSTRACT OF THESIS

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Thesis Title:
Tackling Challenges of Electroencephalogram on an Android Smartphone for Natural Environment Experimentation

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SHORT ABSTRACT

Electroencephalogram (EEG) is a non-invasive technique for measuring brain activity and is widely used in neuroscience, cognitive studies, and clinical applications. Traditional EEG experiments are typically conducted in laboratory environments using stationary systems with multiple electrodes, limiting subject mobility and real-world applicability. Mobile EEG systems, particularly smartphone-based platforms, offer a portable and cost-effective alternative for brain activity monitoring in natural environments. However, challenges related to artifact removal, signal processing, and on-device brain state classification must be addressed to enable practical deployment. This research addresses these challenges through the development of smartphone-based EEG analysis frameworks comprising three major contributions. The first contribution validates CameraEEG, an Android application designed to acquire synchronized EEG and video recordings in natural environments. The synchronized video stream provides contextual information for identifying artifacts and experimental events during EEG acquisition. CameraEEG also enables users to mark audio-visual events of interest during recording. Evaluation using eyes-open and eyes-closed EEG recordings demonstrated the expected enhancement of alpha-band activity during eyes-closed conditions, consistent with established neurophysiological findings. The synchronized EEG and video recordings further confirmed the temporal accuracy of the system. The second contribution presents Embedded-ASR (E-ASR), a novel framework that extends the Artifact Subspace Reconstruction (ASR) algorithm to single-channel EEG recordings. Unlike conventional ASR approaches that require multichannel data, E-ASR employs dynamical embedding to construct an embedded matrix from delay vectors of a single EEG channel, enabling artifact removal and signal reconstruction. The framework was evaluated using semi-simulated and real EEG recordings acquired through CameraEEG. Results demonstrated effective suppression of common artifacts, particularly eye blinks, while preserving underlying neural activity. These findings indicate that E-ASR can facilitate artifact removal in single-channel EEG systems, reducing hardware requirements for mobile EEG applications. The third contribution integrates machine learning into smartphone-based EEG analysis. EEG signals acquired using CameraEEG and preprocessed with E-ASR were used to extract power spectral features for classification. A Support Vector Machine (SVM) classifier was trained using data from a single occipital electrode to distinguish between eyes-open and eyes-closed states. The trained model was successfully deployed in an Android application using TensorFlow Lite, enabling offline EEG state prediction directly on smartphones with limited computational resources. This demonstrates the feasibility of implementing lightweight EEG classification frameworks on mobile devices for real-world applications.