# FINAL PROJECT PROPOSAL

BCI: Detecting Voluntary and Involuntary Eye-Blinks in EEG Signals

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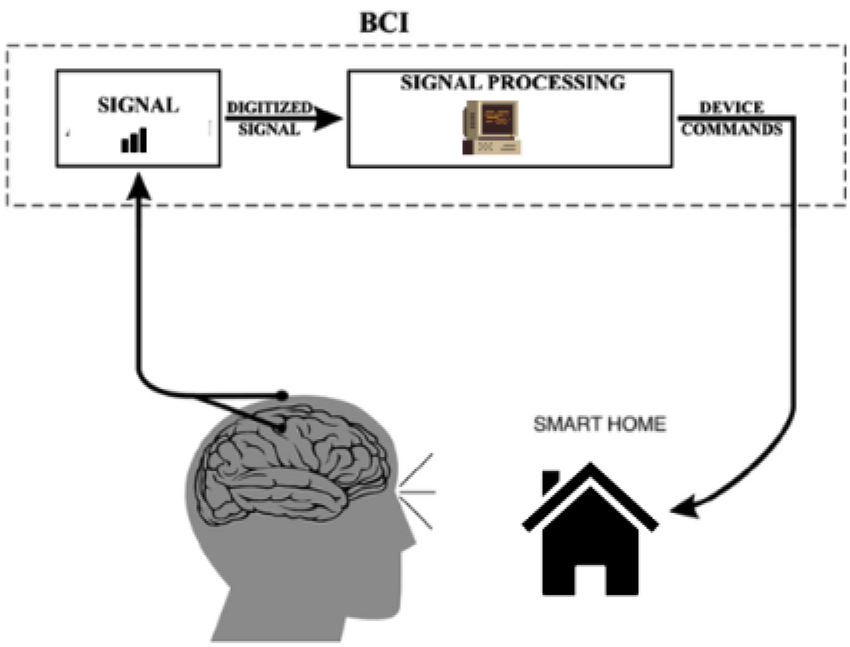
**Introduction**

Electroencephalography (EEG) is a non-invasive technique for measuring electrical activity in the brain, reflecting the synchronized activity of neurons. The proposed system integrates Brain-Computer Interface (BCI) technology with the Internet of Things (IoT) and Artificial Intelligence (AI). Initially developed for healthcare and assistive technologies, BCI has the potential to evolve into a tool for controlling smart devices using mental or physical commands such as voluntary blinks, mental imagery, or specific thought patterns. For example, a smart home system could automatically turn off devices by detecting a user's resting state. While experimental efforts to integrate BCIs with smart devices exist, they remain largely in the developmental stages (Sajda et al., 2003). This project aims to advance human-computer interaction and IoT applications through AI-powered BCIs.




**Data Source and Description**

This research seeks to classify and distinguish EEG signals related to voluntary eye blinks versus involuntary (natural) blinks. In the follow-up study, we plan to explore the detection of resting states.

The EEG-IO dataset contains recordings from 20 subjects performing voluntary single-eye blinks in response to external stimulations. Data was captured using the OpenBCI device and BIOPAC Cap100C from frontal electrodes (Fp1 and Fp2) at a sampling rate of 250 Hz. Each session included approximately 25 blinks.

This dataset was chosen for its high-quality annotations and simplicity (requiring only two frontal electrodes). Collected under controlled conditions, subjects blinked in response to a green stimulus, ensuring consistent data quality and minimizing variability. Signals were wirelessly transmitted to a desktop for processing, and manual video annotations of blinks provided accurate ground-truth labels. Compared to home-collected MUSE EEG data, EEG-IO offers superior reliability and precision, making it suitable for this research.

**Data Processing**

EEG signals are noisy and non-stationary, with significant variability across users and sessions. To address this, preprocessing techniques like wavelet transforms are often applied to decompose signals into frequency bands (e.g., delta, theta, alpha, beta), reducing noise and extracting meaningful features.

Deep learning methods such as CNNs, RNNs, and TCNs are commonly used for eye-blink detection (Agarwal, 2019) but they require substantial computational resources, making them less suitable for portable systems. Alternatively, lightweight, rule-based algorithms leveraging signal processing, correlation, and clustering provide adaptive solutions. We will evaluate these techniques before determining the optimal approach.

**Conclusion**

This project addresses the challenges of noisy, non-stationary EEG signals and user variability in eye-blink detection. By combining signal processing techniques with advanced ML models, we aim to develop robust solutions for brain-computer interfaces and wearable EEG technologies.

**References**

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