

EEG Signal Acquisition and Preprocessing for P300 Detection

In this project, students will implement a real-time EEG preprocessing pipeline to prepare neural signals for P300 event-related potential (ERP) detection. Students will work with EEG data recorded from 16–24 active electrodes placed over central and parietal regions (e.g., Pz, Cz, CPz, P1, P2). The project will focus on filtering, artifact removal, normalization, and epoch segmentation to produce clean, analysis-ready data for downstream classification.

Key Objectives:

1. Acquire or load multi-channel EEG data sampled between 500–1000 Hz.
2. Apply a 0.1–100 Hz hardware bandpass and implement digital band-pass filters (0.1–30 Hz for P300) using a zero-phase fourth-order Butterworth filter.
3. Implement Artifact Subspace Reconstruction (ASR) to suppress eye-blink, muscle (EMG), and motion artifacts in real time.
4. Normalize each EEG channel using z-scoring over a 10-second rolling window to stabilize variance across sessions and subjects.
5. Develop a method to automatically flag and exclude noisy or unstable channels.
6. Segment the continuous EEG stream into epochs from –200 ms to 700 ms relative to stimulus onset, and perform baseline correction using the pre-stimulus interval.

Deliverables:

- A Python or MATLAB script that performs real-time filtering, ASR-based artifact rejection, and epoch segmentation.
- Visualizations showing raw vs. cleaned EEG signals and marked artifacts.
- A brief report explaining each preprocessing step and its role in preparing data for P300 decoding.

Learning Outcomes:

By completing this project, students will:

- Understand the fundamentals of EEG acquisition and event-related potentials.

- Gain practical experience in digital signal processing, real-time artifact suppression, and data normalization.
- Learn how preprocessing affects downstream machine learning and classification accuracy in BCI applications.