SMILE: Towards a Low-Cost Emotional Expression Brain-Computer Interface for Individuals with Severe Paralysis

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1. Introduction

Motivation

- Use low cost, open source electroencephalography (EEG) hardware to develop real-time affect classification systems
- Help those with amyotrophic lateral sclerosis (ALS) express their emotional state through brain-computer interfaces (BCIs)

Research Questions

- Is it feasible to develop a system with similar classification performance to that of other, less economically accessible EEG monitoring systems, despite electrode constraints and additional noise?
- Would such a system be viable in a real-world, unrestricted environment?

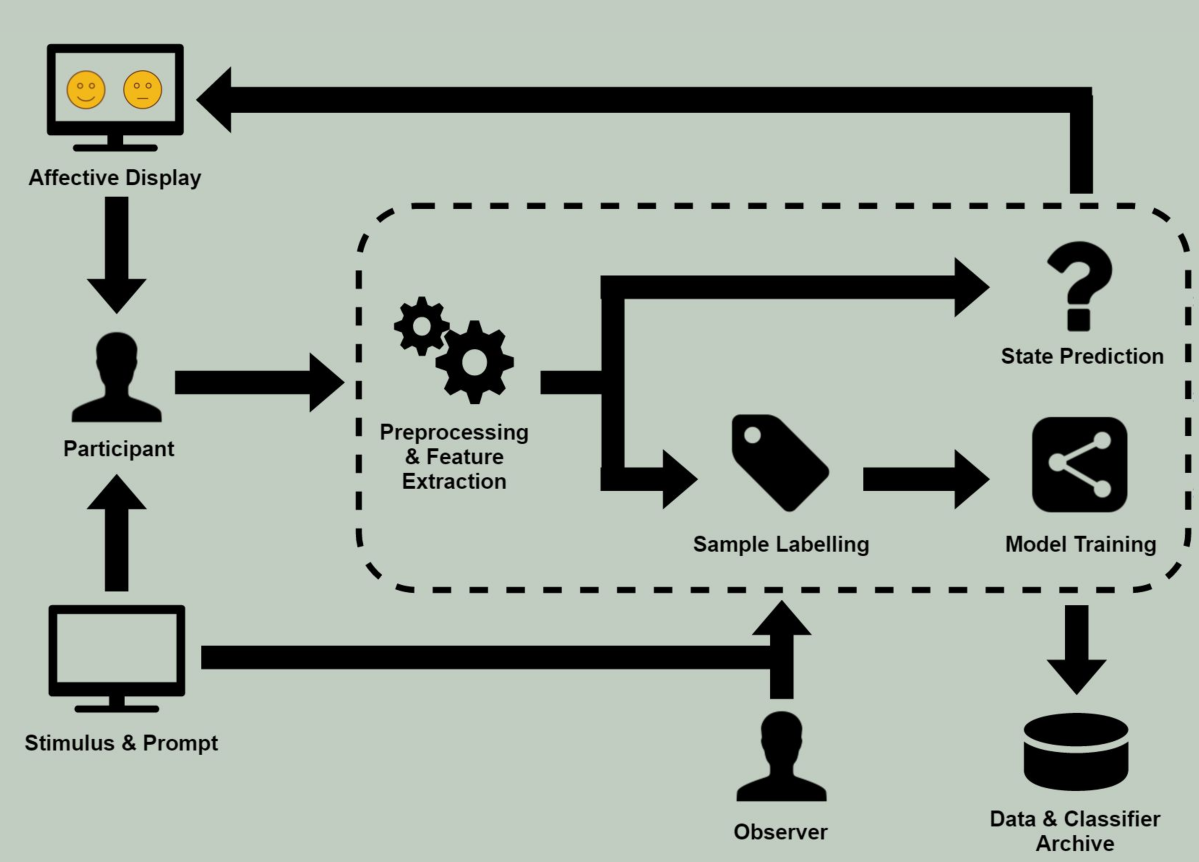
2. Methodology and Pipeline

Desired Phenomenon

- Detect alpha wave activity over the occipital lobe as a measure of arousal and component of emotion

Data Gathering and Labelling

- Participants prompted to open/close eyes in alternation while system autonomously detects and labels preprocessed EEG readings at 250 Hz



3. Results and Analysis

Data Collection

- Open source hardware with single electrode in controlled environment successfully identifies desired phenomenon

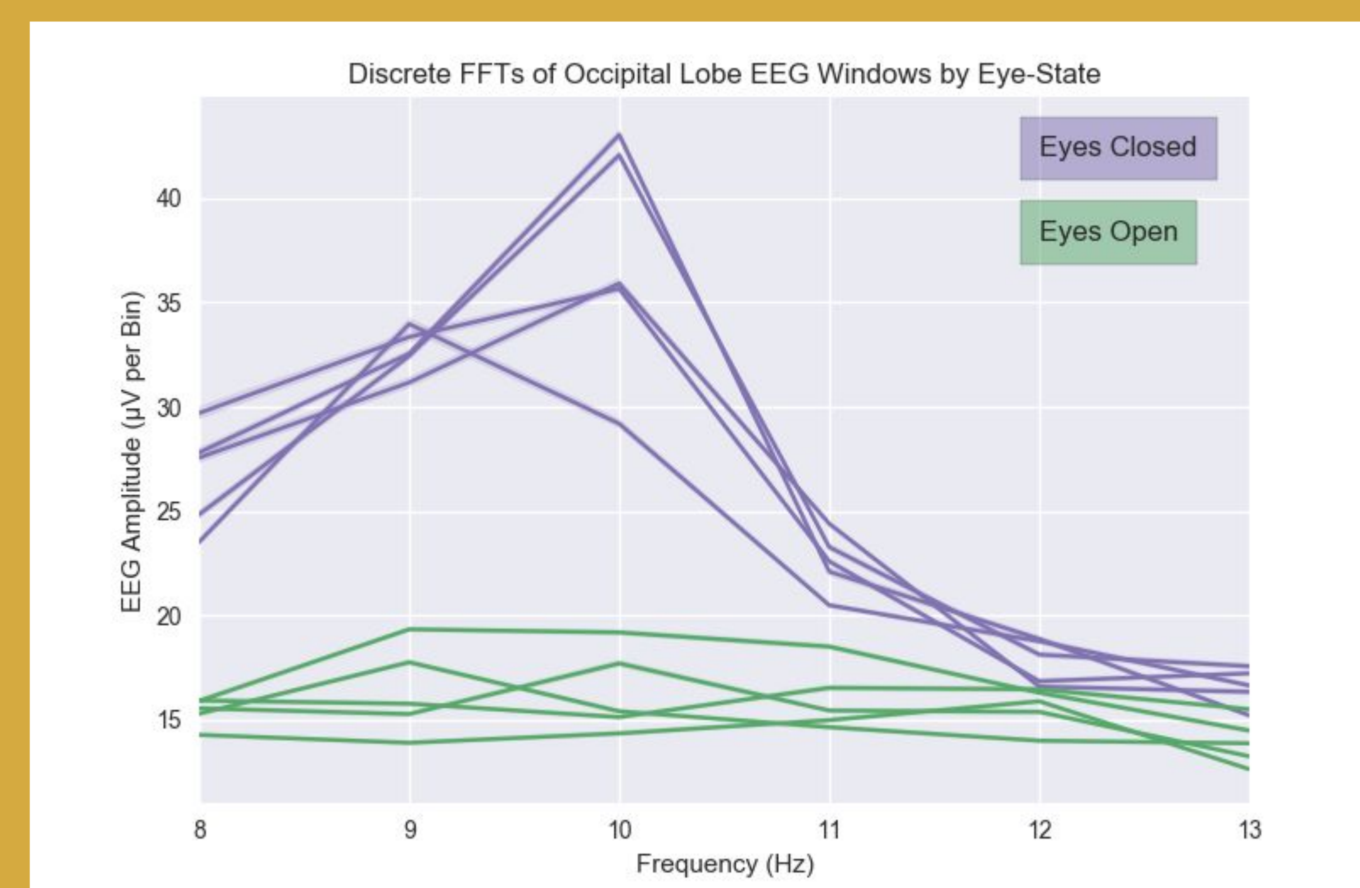


Figure 1. Visualization of discrete FFTs received from sliding window of EEG samples, superimposed by eye-state. (1 second window history.)

Alpha Wave Activity Classification

- System is capable of identifying alpha with classification accuracies exceeding 95% using very small training sets

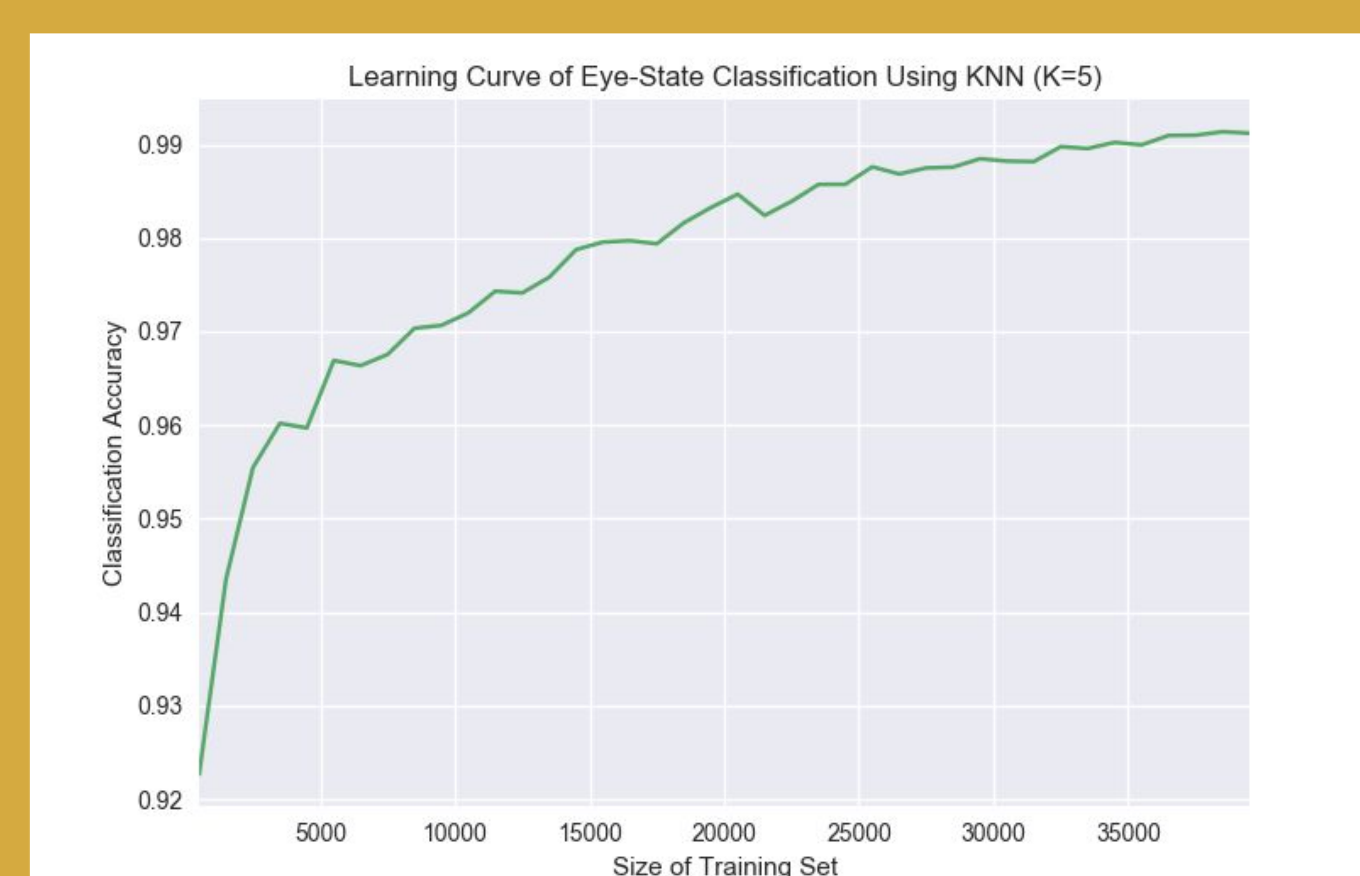


Figure 2. Classification accuracies on independent testing sets of KNN models (K=5) as a function of their training set size.

4. Limitations and Future Work

Limitations

- **Training Periods:** Achieve permissible classification performance while simultaneously minimizing length and invasiveness of training
- **Environmental Factors:** Quantify effects of environmental noise on classification performance in various settings
- **Hardware Constraints:** Maintain comparable classification performance to that of less economically accessible BCI hardware despite fewer electrodes and additional noise

Future Work

- **Valence Axis:** Expand system to identify participant valence using theta band power and acknowledge entire valence-arousal plane
- **Generalization:** Assess feasibility and design of classification models which generalize between sessions, individuals, and stimuli
- **P300 Control Integration:** Link affect classification system to a user interface controlled by P300 phenomenon, requiring little to no motor input

5. References

Lee Y-Y, H. (2014) Classifying Different Emotional States by Means of EEG-Based Functional Connectivity Patterns. PLoS ONE 9(4): e95415. https://doi.org/10.1371/journal.pone.0095415

Vujic, A., Starner, T. and Jackson, M. 2016. MoodLens: towards improving nonverbal emotional expression with an in-lens fiber optic display. In Proceedings of the 2016 ACM International Symposium on Wearable Computers (ISWC '16). ACM, New York, NY, USA, 36-39. DOI: http://dx.doi.org/10.1145/2971763.2971798