EEG Artifact Removal in a Passive P300-Based BCI with Deep Learning

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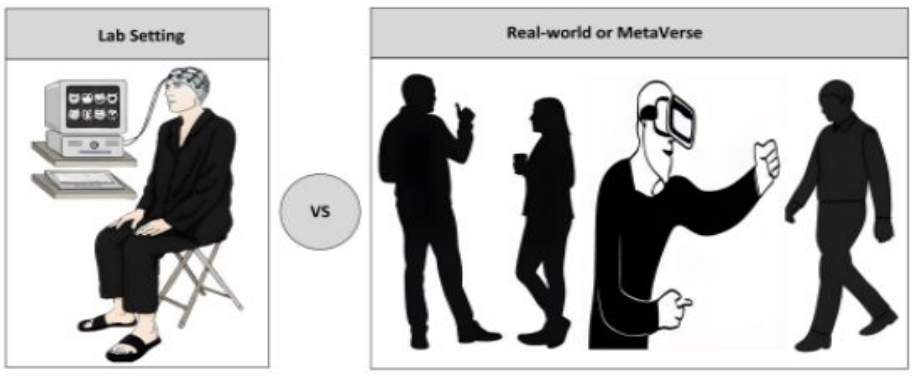
INTRODUCTION

- Brain Computer Interfaces (BCIs) have wide range of applications – treatment/rehabilitation of sensorimotor and cognitive disorders, neuromarketing and advertising, to even gaming and entertainment
- Currently used/tested in a controlled, experimental settings
- Day to day passive use – environmental noise, talking, eye, jaw, and body movements generate artifacts in EEG signal
- To implement BCI systems in real world scenarios - need to filter out artifacts
- P300 - one of the most commonly used event-related potentials (ERP) for BCIs, easy to learn & identify but low SNR & high variance



OBJECTIVE

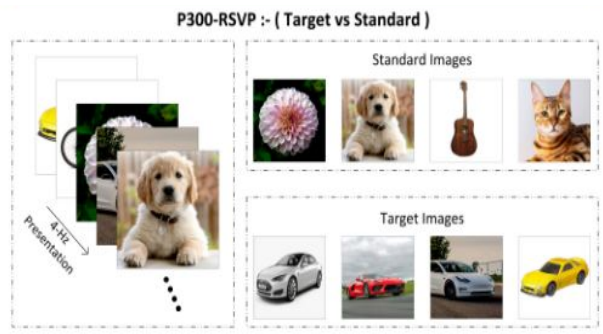
- Improve P300 signal classification in the presence of muscular artifacts
- Compare classical signal processing techniques with deep learning methods

DATA COLLECTION - P300 RSVP TASK

5 subjects, 4 sessions

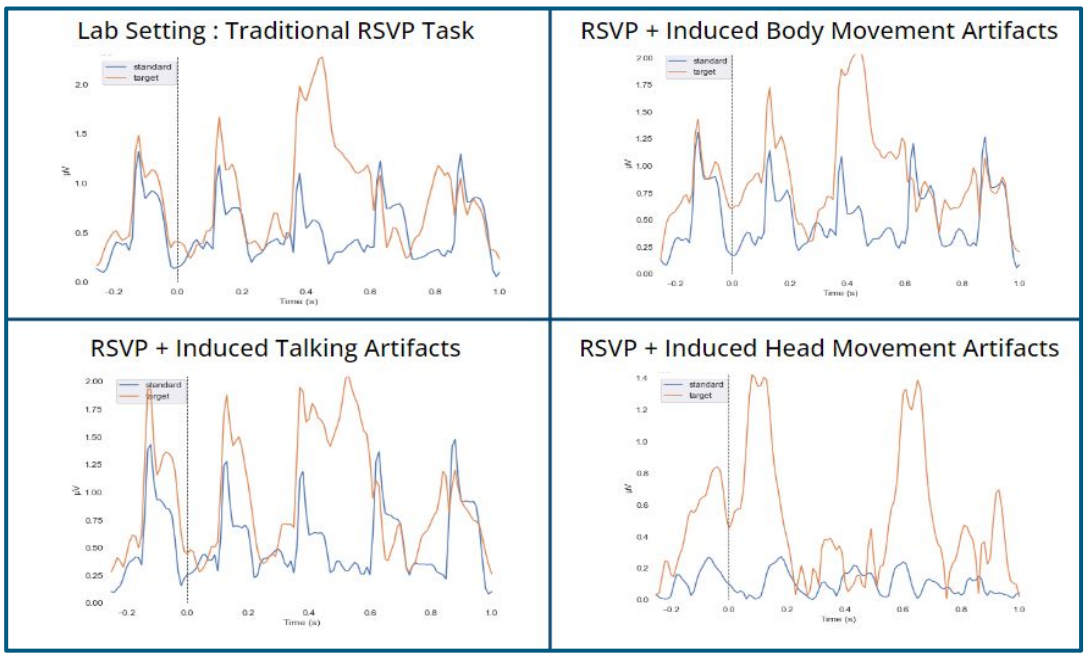
4 trial conditions per session

- clean RSVP task
- RSVP + body movement
- RSVP + talking
- RSVP + head movement



90s, 360 images at 4Hz, 10% target

ERP EXTRACTION & VISUALIZATION



PRELIMINARY RESULTS

Pre-processing: Re-referencing w/ CPz channel, Resampling 1000Hz → 100Hz, Butterworth Bandpass Filter 0.3-30Hz

Dimensionality Reduction: 6 channels (Fz, Cz, P3, Pz, P4, Oz), reduced epoch window from 250-650 ms post-stimulus

Class Imbalance: tested oversampling target vs undersampling standard data

Classification: using reduced time series data & SVM, single - split validation

AUROC scores:

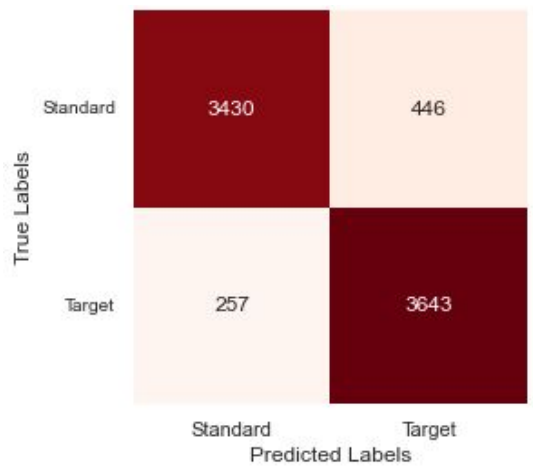
clean data - 0.93,

body movement - 0.91

talking - 0.89

head movement - 0.53

Confusion Matrix: Clean RSVP data



DISCUSSION

- Oversampling target data to balance classes gave better results than undersampling standard data
- Single split classification not valid → need to cross-train & validate
- Artifacts lower the classification accuracy
- Head movement disrupts data the most
- Need further processing / extract different features to filter out artifacts

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ONGOING WORK

- Testing different types of Feature Extraction: AOC, Max Amplitude, PSD, CSP, BSS w/ ICA
- Testing different classifiers: SVM, LDA, Bayesian Ridge, Neural Net
- Testing data w/ existing CNN and LSTM models in literature

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