OpenBCI Fall 2021 Summary

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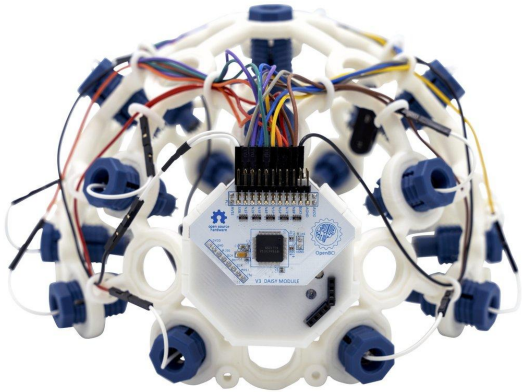
Overview

What is OpenBCI?

- Open source brain-computer interface
- Non-invasive way to measure EEG (brain), EMG (muscles), and EKG (heart) signals.
- Popular tool in recent years in the healthcare industry for prosthetics.
- Comes with a convenient open-source GUI



Ultracortex Mark IV EEG Headset

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OpenBCI GUI

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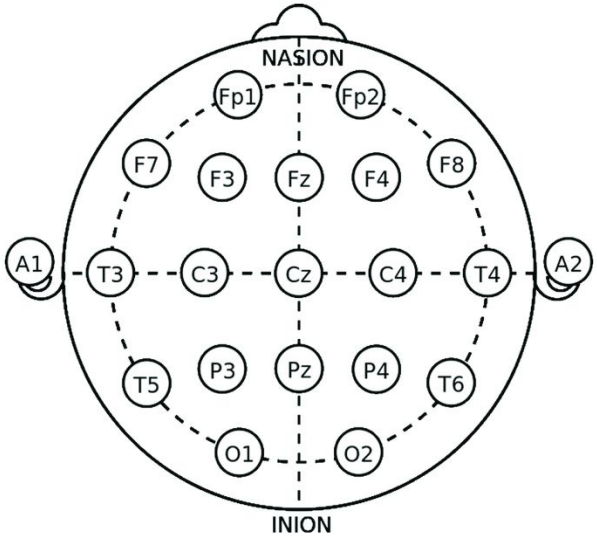
Definitions

- Electroencephalography (EEG)
  - Measures electrical activity in the brain using non-invasive electrodes.
  - OpenBCI Cyton board uses 8 electrodes placed uniquely using the 10-20 system.
- Steady-State Visually Evoked Potential (SSVEP)
  - The brain's response to visual stimulations at target frequencies.
  - Activation is usually see in the visual cortex (O1 and O2 electrodes)
  - Commonly used with flashing LED's for disabled individuals (BCI speller, meal assistance)



10-20 Electrode System

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Project Goals

1. 3D print the frame and assemble the headset.

2. Become familiar with OpenBCI along with the BrainFlow API.

3. Create and execute a SSVEP experiment using a ML algorithm to classify different flashing LEDs with high accuracy.

4. Collect EEG data for the Overcooked AI Simulation game.

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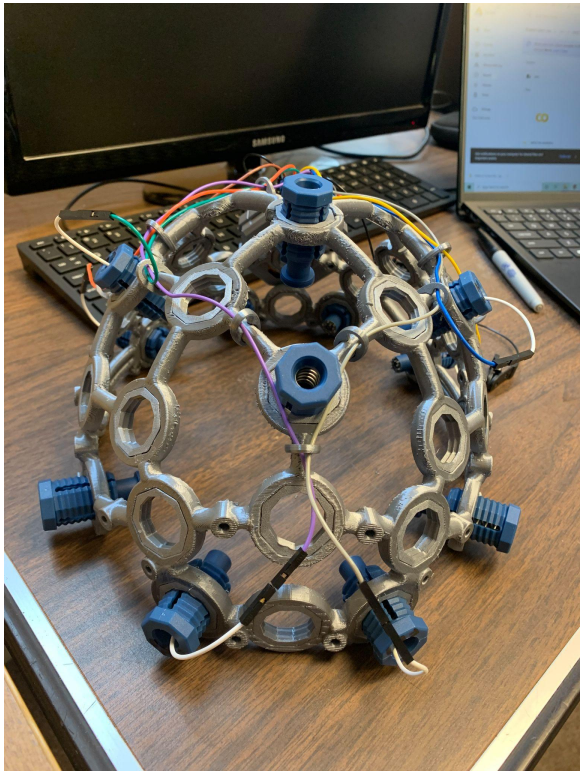
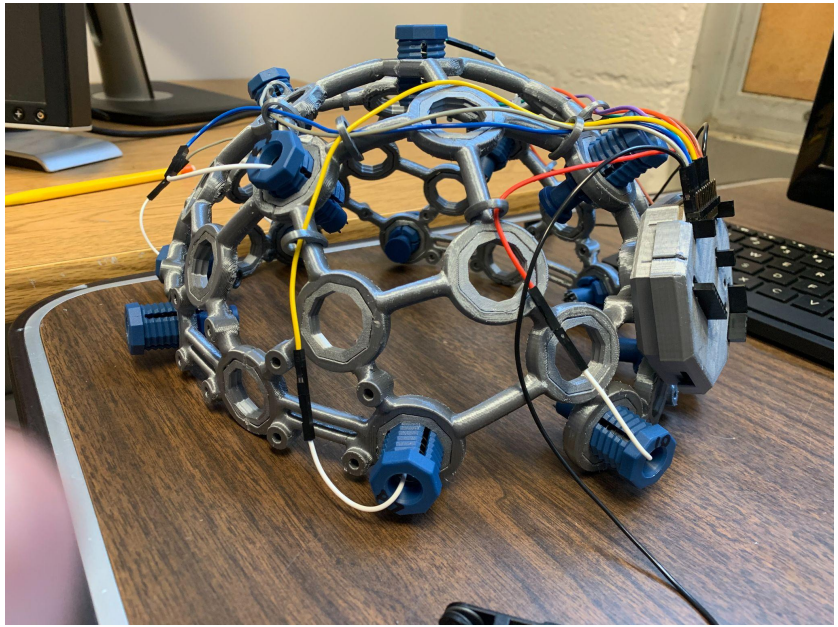
1. Assembling the Headset





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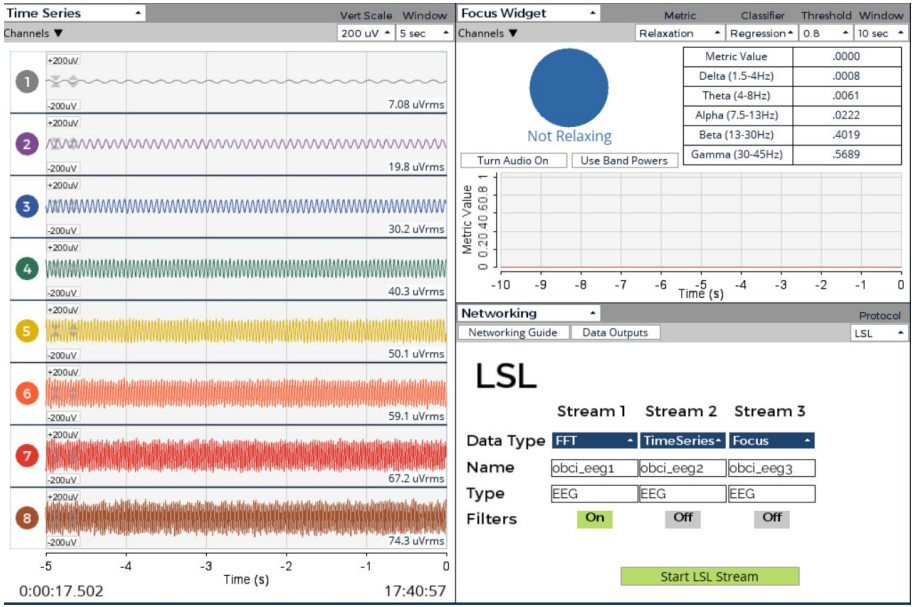
2. OpenBCI and BrainFlow API

OpenBCI

- GUI contains several convenient features
  - Time Series
  - FFT Plot
  - LSL (Lab streaming layer)
  - Focus Metrics

- Ultimately used the GUI for...
  - Making sure electrodes were mounted properly
  - Visualization



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BrainFlow Library

BrainFlow
How Biosensors Work

- Open source API that contains several libraries.
  - BoardShim
    - Reads data from BCI headset and relies on the internal board controller library.
  - DataFilter
    - Signal Processing (FFT)
  - ML Model
    - Calculates metrics such as relaxation and concentration based on the dat

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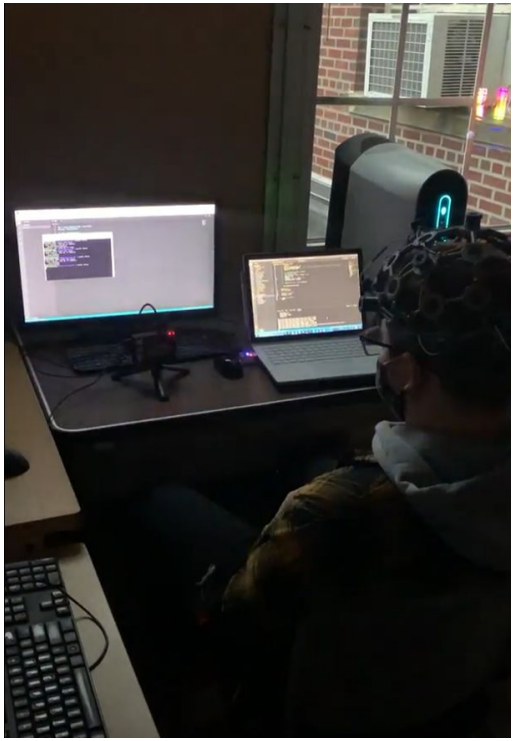
3. SSVEP Experiment

Experiment Setup

- LED flashing at 2.5, 3.0, and 3.5 Hz
- 5 Trials

5 seconds	• Rest
5 Seconds	• DAQ LED 1
5 Seconds	• Rest
5 Seconds	• DAQ LED 2
5 Seconds	• Rest
5 Seconds	• DAQ LED 3
10 Seconds	• Reset



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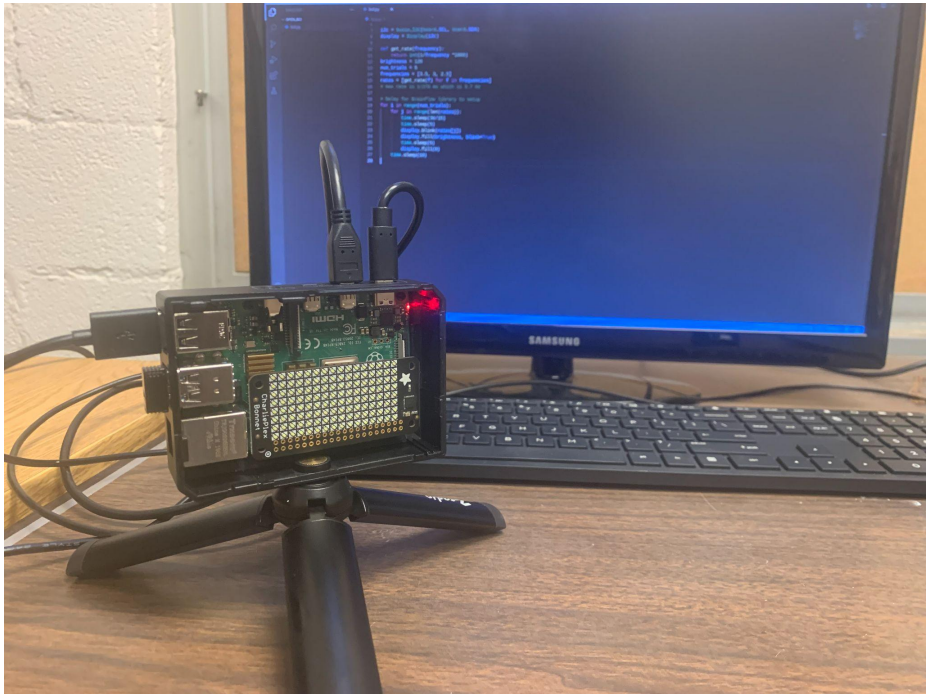

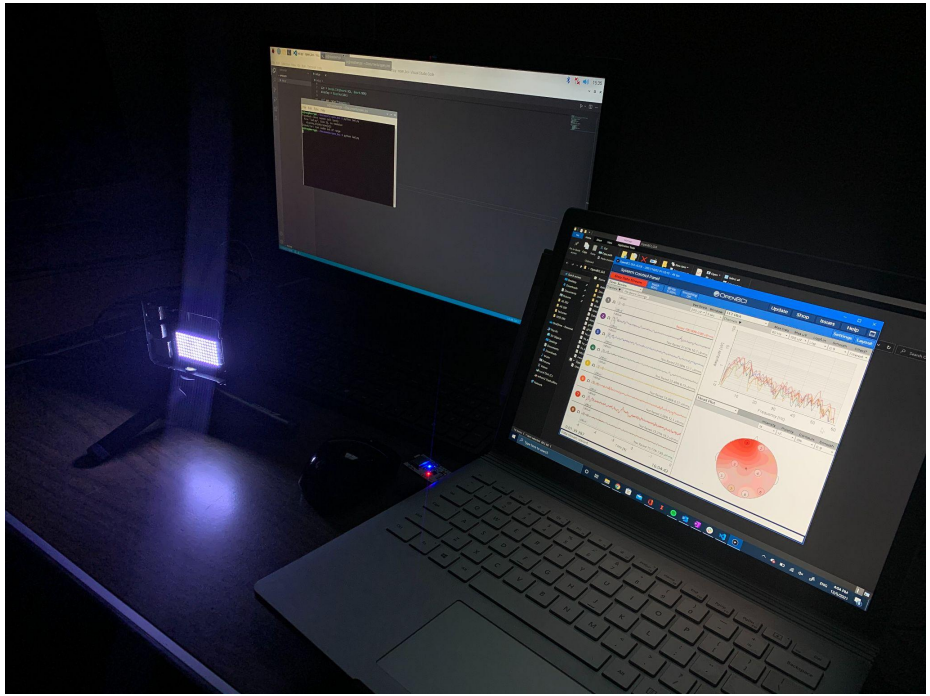

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Data Format and ML ALgorithm

Format

- ~37,000 X 8 Dataset
- Columns: 8 electrodes
- Rows: raw data from the headset

Algorithm

- Hand label all data points with respective LED
- Split data into 80% test and 20 % train
- Shift into Standard-Normal Coordinates
- Train on SVM
  - Radial Basis Kernel (RBF)
  - Hyperparameters: γ=20 C=2
- Test on Model
- Feature Importance using SHAP (SHapley Additive exPlanations)

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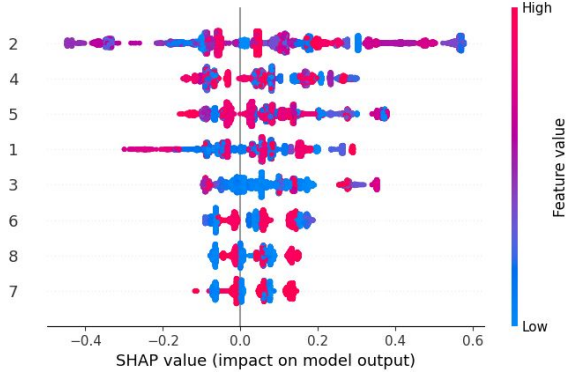
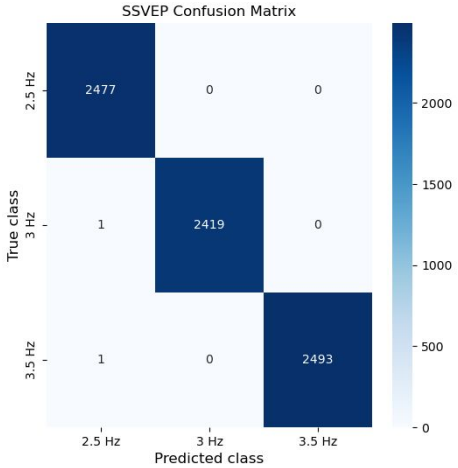
Results





- 99 % Accuracy
- Features 2 (FP2) and 4 (C4) have the most impact on the SSVEP experiment.
  - [Fp1, Fp2, C3, C4, P7, P8, O1, O2]
- FFNN is also accurate, but slow compared to a simple SVM.

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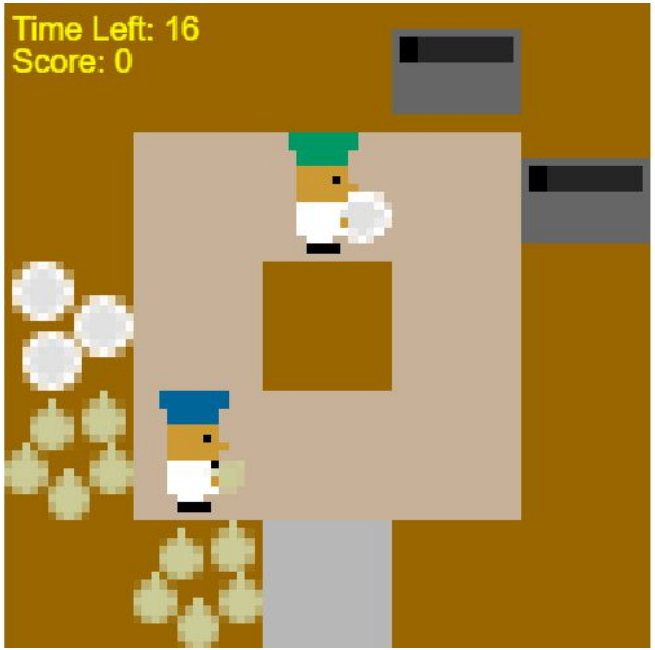
4. Overcooked Data Collection

Overcooked Simulation

- Direct application of human-machine teaming
- EEG data could possibly sense when the user is mad at the agent for doing something wrong.
- EEG data could be be part of the reward function for the agent in an RL algorithm to further improve the agent's performance.



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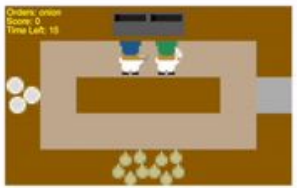
Overcooked Simulation


Cramped Room


Asymmetric Advantages


Coordination Ring


Forced Coordination


Counter Circuit

- Collected EEG data for each game mode
  - 5 Trials
    - 30 second game for each trial

- Wrote down the score along with notable actions that were frustrating about the agent during each trial.

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5. Conclusions and Future Work

Conclusions

- ➔ 8-Electrode non-invasive BCI has proven to be an accurate, cost effective tool for HMT.
- ➔ Model data does not need much preprocessing to have high accuracy (at least for SSVEP algorithms).
- ➔ Implicit feedback can be used to further improve HMT .

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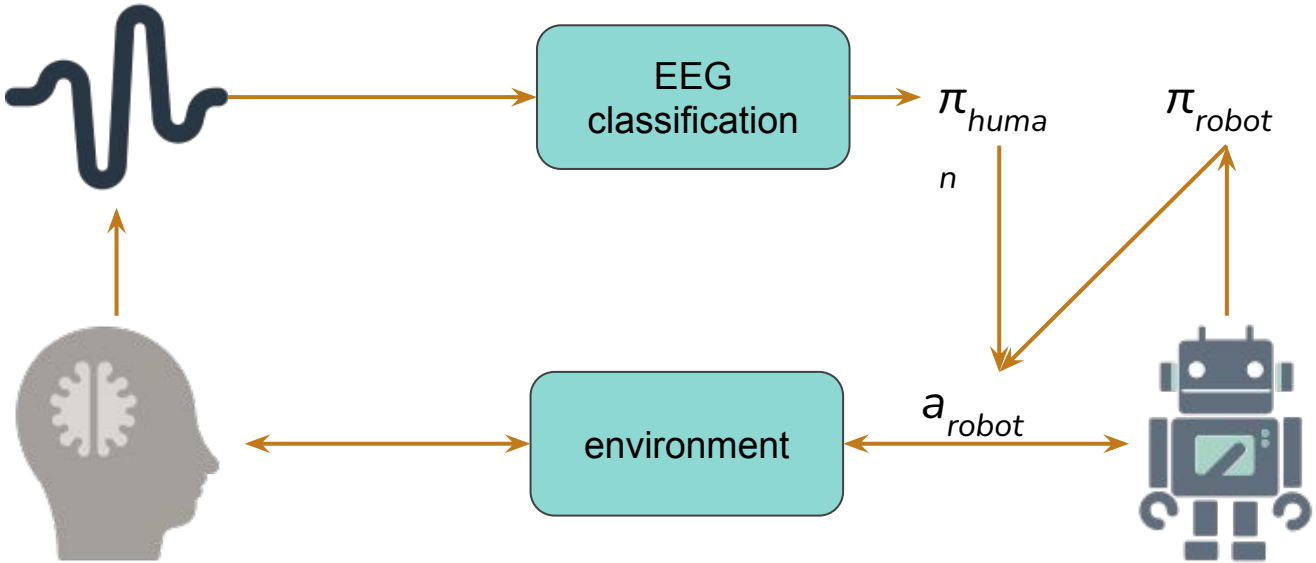
We can incorporate implicit human feedback from OpenBCI to improve human-machine teaming



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Future Work

Can we leverage implicit human feedback from OpenBCI to improve coordination and collaboration on human-machine teams?

- Processing data collected from Overcooked
- Incorporated implicit feedback gained from that data into a human-machine team learning algorithm

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