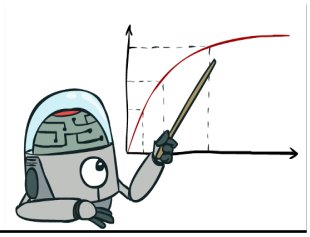
Lab 4: Intro to EEG Signals



ABSTRACT

The goal of this lab experiment is to introduce the student to EEG signals, feature processing and extraction for those signals, and simple classifications.

Please read through the entire document before completing the lab.

1 FILES

There are two files you will **edit**:

1. *Lab_4_EEG_analysis.ipynb*: Jupyter notebook that guides you through the EEG analysis process.
2. *Lab_4_experiment.ipynb*: Jupyter notebook that runs the experiment activity code for this lab.

All other files should not be changed.

2 BACKGROUND

2.1 EEG Signals

The electroencephalogram or EEG is a recording of the biopotentials in the cerebrum of the brain. These potentials are typical recorded at the surface of the scalp and can vary with respect to the emotional, mental, and physiological state of a person. The action potentials and synaptic potentials of an individual neurons are too small to be measured by electrodes. Therefore, an EEG is a measurement of the summation of the electrical signals produce by neurons in a defined area and over a specific amount of time. It is important to note that these neurons need not synchronized but may be producing signals in an asynchronous manner.

EEG signals can be categorized by the four major frequency ranges or brainwaves in which they occur: alpha, beta, delta and theta. The corresponding frequencies, amplitudes, and typical human functionality of the waves are seen in Table 1.

A special system of electrode placement called the 10-20 system is used during EEG recordings. The 10 and 20 refer to percent distances of the electrodes from each other with respect to the size of the patient's head. The letters F, T, C, P, and O in the 10 20 system refer to frontal, temporal, central, parietal, and occipital or essential lobes of the brain excluding central. Also even numbers are located on the right hemisphere and odd numbers on the left hemisphere. The letter z is an indicator of the central line of the head. Figures 2 is a diagram of the 10-20 electrode placement system.

When recording EEG signals there is an abundance of noise sources and artifacts. The most predominate artifact in EEG signals are eye blinks. Other sources include activity from muscles in the face and also eye movements.

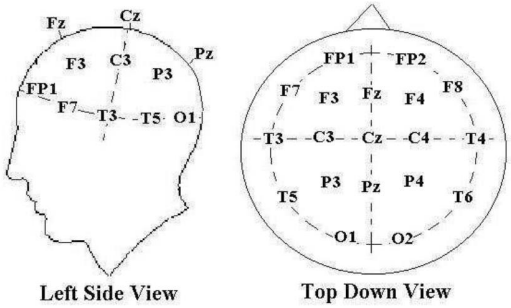


Fig. 1. Electrode Placement System

3 CODE SET-UP

- Follow the steps on https://neurotechx.github.io/eeg-notebooks/getting_started/installation.html to setup you workspace using the command prompt.
- Download and extract zip file from https://github.com/BioRobotics-Spring-2020/Lab_4_2022 and copy the jupyter notebook file to the eeg-notebooks folder.

4 UNICORN EEG CAPS

Unicorn Hybrid Black is a wearable EEG headset that can measure EEG data from 8 Unicorn Hybrid EEG Electrodes, sampled with 24 Bit and 250 Hz per channel for many different BCI applications.

1. Start the Unicorn Suite and check with the TA if the License key is setup.
2. Get yourself familiar with the Unicorn Recorder in the Unicorn Suite using the link https://www.unicorn-bi.com/video-tutorials/
3. Insert the Unicorn Bluetooth Dongle into the USE socket, turn on the EEG headset.
4. Attach the Unicorn Brain Interface to the magnetic docking adapter on the rear side of the cap. Put the Unicorn Cap with the attached Unicorn Brain Interface on your head as shown in Figure 2 and secure it with the chin strap.

Table 1. Typical frequencies amplitudes and brain functionality of different brain waves.

Brainwave	Frequency Ranges (Hz)	Amplitude (μV)	Human Function
α	8 - 13	2 - 100	Awake, Quiet, resting, eyes open.
β	13 - 22	5 - 10	Mental activity or external stimulus.
δ	0.5 - 4	20 - 100	-
θ	4 - 8	10	Emotional stress

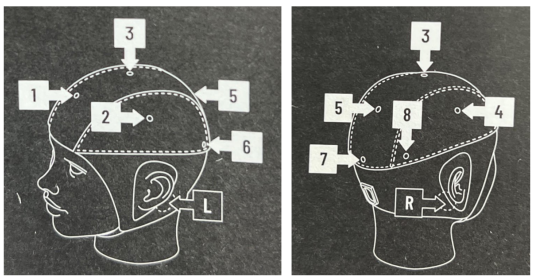


Fig. 2. Unicorn EEG Cap Electrode Markers

5. Put the Unicorn Sticky Electrode on each of the mastoid bones behind your ears (L and R position, as shown in Figure 2). Click the L- and R- clips onto the corresponding sticky electrodes. For this lab, you will only use the dry EEG recording method.
6. For the best signal quality, make sure the cap sits tight on your head and you can feel all electrodes on your head. Twist each electrode back and forth a bit to get through hair and make direct contact with the scalp.
7. The Unicorn Recorder can be used to visualize and record the EEG data. You can also visualize various kinds of artifacts in the EEG signals due to eye blinking/movement and face muscle movement.
    - Record at least 20 seconds of resting EEG data, 20 seconds of EEG data while blinking frequently and 20 seconds of data where you clench your teeth multiple times.
    - Observe the various kinds of artifacts in the EEG data. See which channels are affected by different kinds of artifacts.
8. You can also use DevTools → LSL Interface from the Unicorn Suite to stream the EEG data over LSL layer and use Lab Recorder (used in previous labs) to record the EEG data.

5 DATA COLLECTION:

For this lab, you will be going through P300 experiment. The P300 is a positive event-related potential (ERP) that occurs around 300ms after perceiving a novel or unexpected stimulus. It is most commonly elicited through 'oddball' experimental paradigms, where a certain subtype of stimulus is presented rarely amidst a background of another more common type of stimulus. Interestingly, the P300 is able to be elicited by multiple sensory modalities (e.g. visual, odditory, somatosensory). Thus, it is believed that the P300 may be a signature of higher level cognitive processing such as conscious attention.

- Open a cmd terminal and activate your conda environment
  `conda activate "eeg-notebooks"`
- Open the jupyter notebook application
  `jupyter notebook`
- Open the jupyter notebook file *Lab_4_experiment.ipynb* and make sure the kernel is set to eeg-notebooks (check on the top right corner). If not, go to Kernel → Change kernel and change the kernel to eeg-notebooks.
- Run all the blocks in *Lab_4_experiment.ipynb* to start the experiment. Pay attention and try to count the number of cat photos that appear throughout the experiment.

6 DATA ANALYSIS

Please open the Lab 4 jupyter notebook and follow the directions there.

7 ITEMS TO TURN IN

Please upload your jupyter notebook and a pdf of the notebook (with all the cells ran) to MyCourses. Create a lab report, based on the lab report example on MyCourses.