ECE441 Lab 2

Overview

In this lab, you will collect data on a basic visual cortex exercise that you will subsequently analyse in lab 3. You will collect data for two conditions: eyes open, and eyes closed. In both conditions, the subject should relax their facial muscles and minimise any movement of the eyelids and jaw. The subject should also refrain from moving the head and neck, and keep themselves as stationary as possible.

- During the **eyes open** condition, the subject for data collection should sit still and keep their eyes open, blinking as gently as possible to avoid artefacts.
- During the **eyes closed** condition, the subject for data collection should gently keep their eyes shut, enough to remove visual stimuli (they should not “squinch” their eyes shut tightly). As much as possible, the subject should relax and empty their mind.

The data collected from this experiment, once analysed, should show distinctive behaviour captured in the visual cortex, showing greater synchronous 10 Hz activity appearing in the eyes closed condition when compared to eyes open.

Deliverables

This lab is worth 2% of your overall grade. The grade will be assessed based on in-lab components. There is no report for this lab. The preparation of this lab is not graded, but should be completed *before* the lab session.

You **must** attend the session for the entire duration of the lab, unless you finish early and your TA confirms that you have completed the required deliverables and may leave.

Your grade will be assessed based on the following requirements:
- Demonstrating completion of each section to your TA
- Answering TA evaluation questions during the session

Preparation

Set up your Python programming environment before coming to the lab

- Install Python version 3.11.4 https://www.python.org/downloads/
    - The library versions we use require this version of Python!
- You may choose to install an IDE of your choice. PyCharm is one option that offers a free licence to UofT students.
- Install all requirements in `requirements.txt`
    - If you are using PyCharm, you can open the file `requirements.txt` in PyCharm and it will prompt you to install any requirements that are not met.
    - If you already have these packages installed, make sure they are the right version! We are using features of the latest version of Pandas that are not backwards-compatible.

Prerequisite knowledge for this lab

Labs 2 and 3 will require the following prerequisite knowledge:

- importing non-builtin Python libraries and using their classes and functions
- understanding mutability and its implications
- basic object-oriented programming terminology (classes, attributes, and methods)
- working with non-builtin types in Python (e.g. Pandas DataFrames and Numpy arrays) and calling their associated methods
- knowing how to effectively read documentation pages

If you are rusty on any or all of the prerequisite knowledge, you are encouraged to bring yourself up to speed through self-study and potentially completing some tutorials prior to the lab session. Tutorials for the two libraries that will be used for these labs are found at:

- Pandas: https://pandas.pydata.org/docs/getting_started/intro_tutorials/index.html
- Matplotlib: https://matplotlib.org/stable/tutorials/index

Experiment

You will record the data using the OpenBCI GUI on the lab computers. Once you are finished recording, you will transfer the data to your personal computer to analyse the data in Python.

Data Recording

1. Start a new session in the OpenBCI GUI and set up the headset on one of the group members (as you did in lab 1).
2. You will now record individual trials for each of the “eyes open” and “eyes closed” conditions. Note that the OpenBCI GUI will save the recorded data to a different file every time you click “stop recording”, then “start recording”. Keep the data for eyes open and eyes closed conditions in *separate files,* as you will need to distinguish between them during analysis. Make sure to keep track of which files are for the eyes open condition, and which are for eyes closed.
    - Take recordings for the eyes open condition for 10-20 seconds.
    - Take recordings for the eyes closed condition for 10-20 seconds.
    - Repeat the previous recordings until you have 3 recordings for each condition.
3. Check that you can find the recording files, and open them to make sure there is data being saved. The files should be saved in

    `C:\Users\<utorid>\OpenBCI_GUI\Recordings`

Data Analysis

1. Navigate to `C:/Users/<utorid>/OpenBCI/Recordings` and open the `.txt` file generated from the recording you just performed. The file should start with:

    ```
    %OpenBCI Raw EEG Data
    %Number of channels = 8
    %Sample Rate = 250 Hz
    %Board = OpenBCI_GUI$BoardCytonSerial
    ```

    Followed by a single row that lists the name of the data found in each column. The remainder of the file consists of the timeseries data of the recordings, where each row represents a point in time and each column the value of a particular signal at that point in time. The EEG signals are found in the channel The time interval between each row is the sampling period, calculated as 1 / (sampling rate).

    Transfer your data to your personal computer.

    Your files will not be persisted on the lab machines. If you would like to keep your recording files, you **MUST** transfer the files to the W:\ drive, email them to yourself, save them to a USB drive, etc.

2. Open `lab2.py`. Make sure you understand the relevance of the global constants with respect to the recording file. Ask your TA if there are any that are not clear.
3. Complete the function `load_recording_file` according to its docstring.
    - use the pandas function `read_csv` https://pandas.pydata.org/docs/reference/api/pandas.read_csv.html
    - make sure to skip the first "few" rows of the `.txt` file, as those are not part of the tabular timeseries data
4. Make sure your `load_recording_file` function works by running the code in the `__main__` block and visually comparing it to what you see when you open the `.txt` file. Note that some of the columns are removed/renamed due to the call to `utils.clean_eeg_dataframe`; pay attention to the new column names as you will need it to complete step 6.
5. Complete the function `is_eeg` according to its docstring.
6. Complete the function `plot_eeg_data` according to its docstring. You will need to:
    - recover timestamps from the dataframe
    - isolate columns with EEG data (e.g., ignore columns with accelerometer data)
    - plot on the existing axis object using Matplotlib's subplots interface https://matplotlib.org/stable/gallery/subplots_axes_and_figures/subplots_demo.html, plotting each EEG channel with the colour assigned to it in the OpenBCI GUI

    See Figure 1 on the following page for the result of plotting the sample data provided.

7. Use your functions to load in each recording file for the data you collected in the data recording task. You will continue to work with this data in lab 3, so if you notice any major issues in the data you collected in this session, you may wish to repeat the recording procedure.

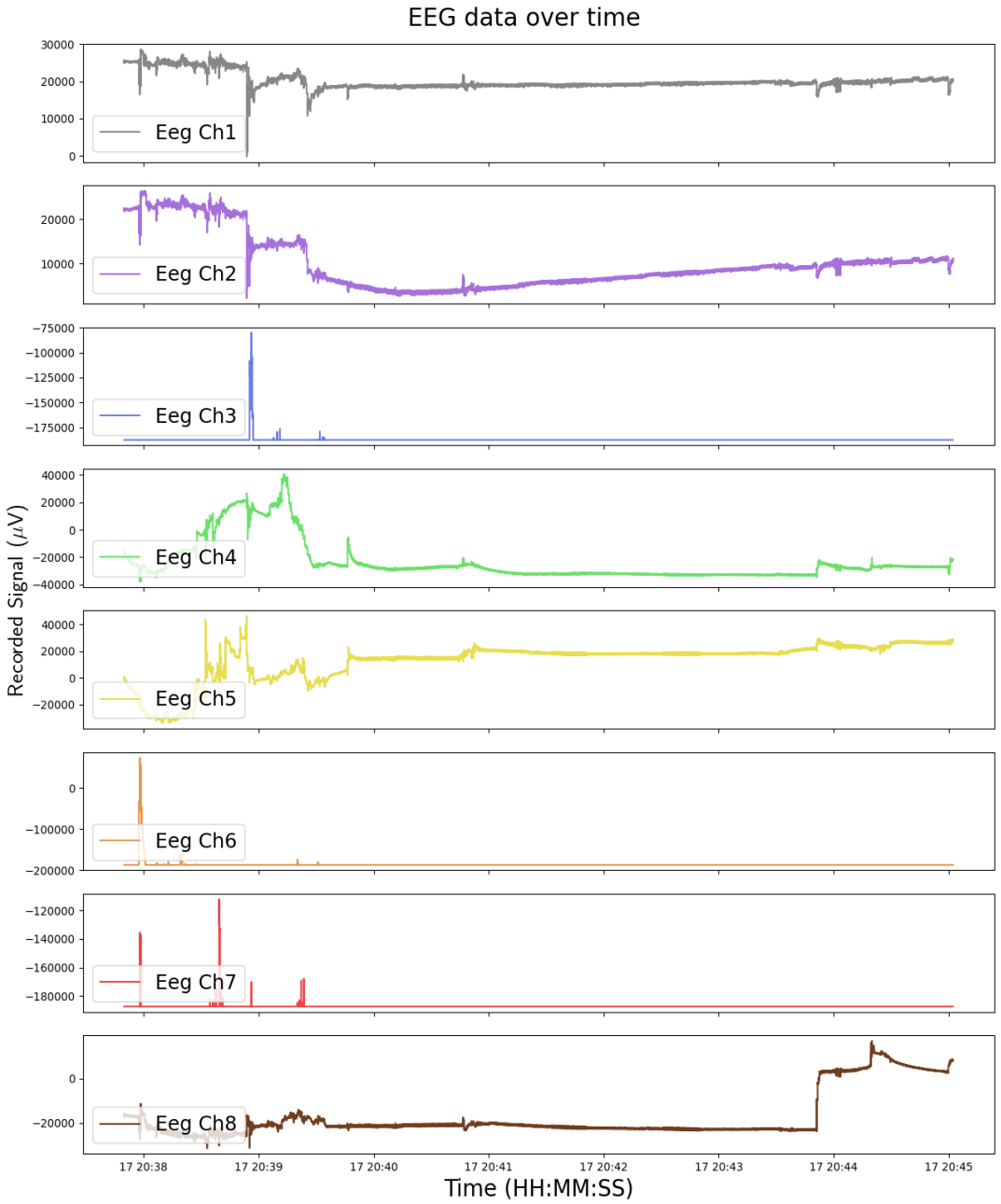

Figure 1: result of plotting the data given in `data/sample_data.txt`

Wrap-up

1. In the GUI, click “end session”.
2. Power off the control board by sliding the switch back down to the middle position (there are 3 positions in total, do not slide the switch all the way to the bottom position).
3. Place all of the components back in the boxes and return the box to your TA.