COGS118C - Neural Signal Processing

Final Project

Project Overview

The goal of the final project is to apply the concepts learned in class to a dataset of your choice and visualize the results, to address a mock but concrete research question. It's designed to assess your ability to correctly apply and evaluate the analytical tools appropriate for a given situation, as well as to communicate your process and findings effectively. **You will work in teams of 3 or 4 members**, and the project should include the following components (not necessarily chosen in that order, i.e. you can choose your research question after picking which methods you want to implement):

Research Question & Hypothesis

The research question(s) can be targeted or exploratory. It can be straightforward, and must be addressable within the scope of your data and analysis toolkit. As a rule of thumb, ask yourself whether you can produce a number or a graph (or graphs) that addresses the question. Yes/no questions or finding relationships between variables are usually tractable. It's perfectly acceptable to perform a replication or variation of a finding from a scientific publication. The research question can be about the methods themselves (e.g., compare methods or parameters). You are also asked to make an informed prediction (hypothesis).

Application of 3 Methods

This is the main component of the project: you are required to choose, implement (in Python), and apply **at least 3 methods** we learned in the class to a dataset of your choice to answer your research question. Examples include: ERP (averaging), time-frequency analysis, cross-frequency analysis, spike-LFP analyses, etc. They can be 3 unrelated methods to address 3 different questions, 3 methods that chain together to answer a single question, or 3 methods that addresses the same question in parallel, but from complementary perspectives. You will communicate the results of your analysis in the presentation and report (detailed below).

Background Research

You are expected to reference at least one scientific publication that has either used the methods you proposed, or attempted to address the research question you asked. Either or both options are acceptable, but the latter will very likely include the former. You are expected to explain and evaluate the analysis choices made in that publication, similar to what we've done for the assigned readings during reading discussions.

Presentation & Report

Your team will give a **15 minute presentation (10 min talk + 5 min Q/A period)**, with visual aid (Jupyter notebook or PowerPoint), as well as submit a **short report in the form similar to a Science paper** that communicates the above aspects of your project, as well as your findings.

Project Deliverables and Deadlines

Team Formation & Project Proposal: 11:59pm, July 27

You are not required to submit a proposal. However, doing so will allow you to get early feedback on your project, as well as for me to make sure you are on track. Proposal (1 page maximum) detailing your research question, method choices, and analysis plan submitted through Gradescope before the deadline will receive feedback comments before July 31. Please let me know if you do not have a team by July 24.

Project Presentation: Timeslot for Class Final, 3-6pm, August 2

15 minute (10-12 min talk, rest Q&A) presentation on your research question, literature review, method choices, and analysis results. Order will be randomly chosen.

Code: 11:59pm, August 3

In the spirit of open and reproducible science, all analysis code and visualization should be viewable on GitHub, either in the form of Jupyter Notebooks or python scripts and png figures. Cloning and running your code by a third party should **reproduce exactly all results and figures reported**. Please make sure to comment/document your code.

Written report: 11:59pm, August 3

The report (roughly 5-8 pages, double spaced) should emulate a condensed version of a scientific publication, describing your project goals and results, **similar to the papers we read for R1 and R3**. Because all code is online, detailed technical descriptions of the method is not required. However, it must include the following sections:

- **Research question and hypothesis**
- **Discussion on existing research (at least 1 paper)**
- **Methods and parameter decision**
- **Analysis results**
- **Conclusion with respect to your research question and hypothesis**
- **Potential limitations of the methods chosen**
- **References**
- **Contribution statement detailing the work done by each team member**

The submitted report can be in the form of a text document with embedded figures, or a pdf generated directly from a Jupyter Notebook, with all required sections embedded within.

There is no hard page limit for the report. It should contain as much text as required for us to understand what you did and what you found (in conjunction with your presentation), and no more. You may be penalized if details are missing that impedes our understanding of your work, while writing too much when it's not necessary is just a waste of your own time.

Datasets

You will be given **3 curated datasets** from real neuroscience experiments. There is an accompanying Jupyter Notebook that explains the experimental details and variables of each dataset. Briefly, the datasets are:

1. **Rat local field potential** (LFP, 2 channels in frontal cortex, 1000Hz sampling rate) with spikes, while the animal is freely moving. Sleep and awake periods are annotated.
   Source: https://crcns.org/data-sets/fcx/fcx-1/about-fcx-1
   Publication: *Watson et al., Neuron, 2016*
2. **Human patient electrocorticography** (ECoG, 2 channels in motor region) during simple finger movement task. Freely timed trials (no trial timestamps), but finger movement is tracked via accelerometer channel.
   Source: https://exhibits.stanford.edu/data/catalog/zk881ps0522
   Publication: Miller et al., JNeuro, 2007
3. **Monkey electrocorticography (**ECoG, 3 channels in multiple locations) recorded during resting wakefulness and anesthesia.
   Source: http://neurotycho.org/
   Publication: Yanagawa et al., PLoS ONE, 2013

Recording your own EEG

You have the option of record your own 4-channel EEG using a MUSE headset while doing a behavioral task of your choice (can be as simple as resting, or eyes open vs. eyes closed). If you wish to do this, please inform me by **July 25**, and you are **required** to submit a project proposal detailing your experiment by the proposal deadline (**July 27**). We will then schedule a time together for you to borrow the headset. Failure to complete the two requirements above will disqualify you from using your own EEG, as those early checkpoints will be crucial to keep you on track, in case of unexpected technical difficulties (there will be many).

Find your own data

You also have the option of finding your own dataset. Each of the data sources listed above have multiple datasets you can explore, and there are various other online databases. However, I would not recommend this unless you have some familiarity in neuroscience and in working with publicly available data, as the curation quality can vary, as well as the experimental details.

Assessment Rubric

This project is designed to assess your ability **to correctly apply the tools learned in this class, to evaluate and make analysis decisions, and to effectively communicate those analyses and critiques**. Correct application clearly communicated will result in a B grade, as that is the expectation by the end of this class. We will use the following rubric when evaluating your project during the presentation and when reading your report.

Project: _____ **Total: / 24 (25 available)**

Group Members: _____

Project Components	**Below Expectation (C/D grade)**	**Meets Expectation (B grade) [20 total]**	**Exceeds Expectation (A grade) [+5]**
Research Question	- Missing, vague, or intractable research question	[/2] Has an explicit and tractable research question	
Hypothesis	- Missing hypothesis, or incorrect deduction of possibilities	[/2] Logical inference of outcome given question and analyses	[+1] Raise several possibilities that hinge on parameter decisions
Background Research	- Choice of background literature is unrelated or irrelevant to question	[/2] Correctly identified example of relevant previous study	[+1] Critical evaluation of analysis and methods in chosen study
Method Application	- Wrong choice of methods and/or parameters for question	[/6] Correct application of methods for question, including parameter choices (1) [/2], (2) [/2], (3)[/2]	[+2] Comparison of methods and parameter choices to evaluate the robustness of findings & methods
Result Visualization	- Incorrectly labeled or missing labels; wrong visualization method	[/2] All plots are correctly labeled, includes legends & figure captions	
Conclusion & Limitations	- Lacking discussion of how the analysis addresses your question	[/2] Interpretation of the analysis wrt to question and hypothesis	[+1] Includes critique of where your analysis falls short / is ambiguous
References & Contributions	- Missing or incomplete	[/1] Both sections are present	
Report & Oral Presentation	- Presentation/report impedes understanding	[/2] Clear and concise communication	
Code	- Disorganized/ undocumented	[/1] Organized & documented	