EEE 482/582: Computational Neuroscience

Final Project

(Due 31/05/2020, 17:00)

Instructions:

1. Prepare a report to be uploaded on Moodle.
2. The report should be typeset, **no handwriting is allowed**.
3. The report should be submitted as **a single PDF file**. No other format accepted.
4. **Only one student should submit the report on behalf of the entire group.** The first page of the report should clearly list the names of the group members.
5. The file should be named as: `'name_lastname_studentid_final.pdf'`, where the credentials are from the submitting student.
6. Your report should contain the following sections: **Abstract, Introduction, Methods, Results, Discussion, References, and Appendix**.
7. Your report should be **5-10 pages long** at most, with **at least 9 pts** font size.
8. Page numbering should be used.
9. **Your submission will be considered missing, if you fail to follow any one of the above conventions, i.e., 0 points automatically regardless of content.**
10. No late submissions are allowed.

Part	Points	Your Score
Abstract	5	
Introduction	15	
Methods	20	
Results	20	
Discussion	15	
References	5	
Appendix	20	
TOTAL	100	

General Instructions

Partners: You must complete the assignment in groups of three. Groups can include both graduate and undergraduate members. Once you form your group, **you have to send an email to your TA that lists the names of group members and the project that you have selected by 15 April 2020**. **The title of the email should be *Comp Neuro Spring 20 Project Group.*** Students who have not sent an email by this deadline will be randomly matched and assigned projects. In any case, you won't be allowed to change these preferences/assignments later.

Topics: The work that you implement must fall within the score of topics covered in EEE 482/582. **For this reason, you are required to select a project from the list provided below.** If you have difficulty in selecting a project, you are recommended to find other research/review articles on the listed topics to gain perspective about potential research questions/problems that you can address.

Types of projects: Regardless of the topic selection, your project should fit in with the following guidelines:

a) Application of advanced computational techniques to new, realistic datasets. (i.e., applying an algorithm covered in class to a dataset as simple/small as the ones included in your homeworks is NOT allowed).

b) Development of new algorithms or application of algorithms beyond those that were covered in class to existing realistic datasets.

c) Replicating a major portion of computational analyses performed in a research publication, which considers one of the topics within the scope of EEE 482/582.

d) You may either write your own code for computational analyses, or use existing software. However, if you choose to use existing software, then the analysis that you perform should be more sophisticated and challenging to implement in-house.

List of Projects

1. **Visual Object Recognition:** Implement multi-voxel pattern analyses methods (based on some type of classifier) to decode the category of visual stimuli viewed by a human subject based on their recorded brain activity. Download experimental data from `https://openfmri.org/dataset/ds000105`. See [6] for potential analyses.

2. **Functional Connectivity:** Perform functional connectivity analyses on functional MRI activity recorded from human subjects under resting-state. Download fMRI data from the Human Connectome Project website.

3. **Structural Connectivity:** Perform diffusion-tractography analyses on structural MRI data recorded in human subjects. You may download sample datasets such as `http://www.cabiatl.com/Resources/Course/tutorial.zip` or similar.

Project Writeup

Report: You have to submit a report that is 5-10 pages long, typeset in 9 pts font or larger, in PDF format. For reports that exceed the page limit, only the first 10 pages of the submission will be evaluated. **The due date is 31 May 2020**. The report should contain the following sections: Abstract, Introduction, Methods, Results, Discussion, References, Appendix.

Abstract: A one-paragraph summary of all major aspects of your report from Introduction to Discussion. No references should be given, and the abstract should be self-contained.

Introduction: Establish the topics under study by briefly overviewing the existing literature. State the purpose of your work, and why it is an interesting/important question to tackle. Explain the methodology that you will be using to address these questions, and what outcomes are expected as a result of your efforts.

Methods: Explain the data that you will be examining. If working on an experimental dataset, you should describe the experiment that was used to collect the data. If working on a simulated dataset, you should describe the conditions under which the simulation takes place. Describe all qualitative/quantitative analyses used to examine the data. If parameter/model selection is necessary in the analysis routines used, clearly state the motivation for the specific set of parameters/models selected. The methods section should be fully referenced, and should contain subheadings for explaining different methods/analyses.

Results: Present your key results, illustrate your outputs visually with the help of figures and tables. Detailed numbers/plots should be provided in illustrations, and each figure or table should contain a paragraph-long, self-contained caption that explain the contents. Information presented in a table or a figure should not be covered at a microscopic level in the main text, but figures/tables should be referenced in appropriate sections and the main trends/results should be stated in the text. Statistical significance of any measurement should be reported along with the effect size.

Discussion: Interpret your results in light of previous work on the project topic. Did you run any new analyses on existing data? If so, did these analyses tell you anything new about neural structure or function beyond current knowledge? Did you apply advanced analyses on new, real-life datasets? If so, what structure did you recover from these datasets compared to other datasets? Which parts of your analyses worked, and which failed? What could you do to improve your results? Did you reach the goals that you set out in the Introduction? Did your work produce the expected outcome?

References: A list of all referenced material formatted according to standard conventions used in journals. Crude, unformatted lists are not acceptable.

Appendix: All code written or used during the implementation of the project (including all stages of file handling, data processing, computation/modeling, hypothesis testing, visualization) should be placed in this Appendix section.

References

[1] B. A. Olshausen and D. J. Field. Emergence of simple-cell receptive field properties by learning a sparse code for natural images. Nature, 381(6583):607-609, Jun 1996.

[2] B. A. Olshausen and D. J. Field. Natural image statistics and efficient coding. Network, 7(2):333-339, May 1996.

[3] Yan Karklin and Michael S Lewicki. Emergence of complex cell properties by learning to generalize in natural scenes. Nature, 457(7225):83-86, Jan 2009.

[4] D. D. Lee and H. S. Seung. Learning the parts of objects by non-negative matrix factorization. Nature, 401(6755):788-791, Oct 1999.

[5] Simon Osindero and Geoffrey Hinton. Modeling image patches with a directed hierarchy of markov random fields. In J.C. Platt, D. Koller, Y. Singer, and S. Roweis, editors, Advances in Neural Information Processing Systems 20, pages 1121-1128. MIT Press, Cambridge, MA, 2008.

[6] J. V. Haxby, M. I. Gobbini, M. L. Furey, A. Ishai, J. L. Schouten, and P. Pietrini, Distributed and overlapping representations of faces and objects in ventral temporal cortex., Science, vol. 293, no. 5539, pp. 2425–2430, Sep. 2001.