PSY 435/535 - Computational Neuroscience: Analysis of Single & Multi Units Neural Data

Instructor: Jean-Marc Fellous (fellous@email.arizona.edu)

Fall 2024: Day: Tu, Th; Time 11:00am-12:15pm – Psychology 304

http://amygdala.psychdept.arizona.edu/IntroData/

Course objectives

Major advances in neuroscience are often accompanied by new and creative ways of analyzing and displaying data. This course will cover the basic methods available for the analyses of point processes (e.g. single unit and multi-units neural recordings). The course will be divided into a theoretical portion, where the methods and their limitations will be discussed and a practical portion where students will be required to implement them. During this course students will 1) work on analyzing actual and simulated neural data, 2) learn to write modular and reusable analysis code, and 3) learn to assess the quality and validity of their analysis results. Knowledge of Matlab and of some basic neurobiology are strongly *recommended*.

Instructor's availability

Dr. Fellous will hold office hours on TBD at TBD in room Psychology 517.

Texts: The course is constructed around key/classical publications accessible online.

Suggested support textbooks (not mandatory):

- Theoretical Neuroscience (Dayan and Abbott)
- Mathematics for Neuroscientists (Gabbiani and Cox)
- Matlab for Neuroscientists (Wallisch et al.)
- Neuroscience (Purves et al.)
- Numerical Recipes in C (Press, Teukolsky,Vetterling, Flannery)
- Spikes (Rieke et al.)

Grading Policy:

There will be 1 midterm exam, 1 final, 1 end-of-semester project and 4-6 homeworks. Few quizzes will be for extra credits. The final is comprehensive. Midterm and final exams cover assigned readings and lecture material. The final grade will be assigned as follows:

Graduate Students:		Undergraduate Students:	
- Final	**30 %**	**- Final**	**25 %**
- Midterm1	**20 %**	**- Midterm1**	**20 %**
- Final project	**20%**	**- Midterm2**	**20 %**
- Homeworks + class participation	**30 %**	**- Homeworks + class participation**	**35 %**

Final examination or project: The Final will be comprehensive and will cover all in class lecture materials and slides. The Final project will be defined between individual graduate students and the instructor week9-10. Updates will be provided and discussed weekly until week14 (project presentation). The project evaluation will involve anonymous peer review (50%) and instructor review (50%).

Syllabus Outline (subject to change, see website)

Week1 Introduction to biophysical neurons and neural networks

Week2 Basic recording techniques: single and multi unit data. Generating your own data: surrogate datasets, NEURON simulations.

Part I: Single unit data analyses

Week3 Spontaneous activity: Spike count, firing rate, CV, return maps, fano factor.

Week4 Stimulus driven activity: Histograms, spike triggered average, PSTH.

Week5 Reverse correlations, tuning curves, receptive fields, discriminability and ROC curves.

Week6 Rhythms and oscillations, autocorrelation, field potentials, power spectra and spectrogram.

Week7 Displaying single unit data and analyses. **Midterm1**.
Week8 Spike timing and spike patterns. Reliability, precision.

Part II: Multi-unit data analyses

Week9 Population vectors, cortical maps. Start defining final project (Grad students).
Week10 Dimension reduction: PCA and ICA.
Week11 Cross correlations, joint-PSTH, synchrony, explained variance and coherence.
Week12 Displaying multi-unit data and analyses. **Midterm2.**
Week13 Introduction to information theory. Measures of information (Shannon Vs Fisher).
Week14 Projects presentations.

Learning Outcomes:

Upon completion of this course *Undergraduate Students* will be able to 1) learn to quickly read and understand data analyses publications in the general field of Neuroscience, 2) interact with and manipulate real data obtained from experiments in multiple preparations, 3) identify the theoretical foundations of standard data analyses methods and 4) to compare and contrast different ways to present data analysis results.
Upon completion of this course *Graduate students* will (in addition) be able to design, implement and present a neural data analysis project. This includes research-level literature search and critical thinking of published research. Students will also be able to perform analyses of code failures, and achieve creative ways to display complex data.

Attendance Policy

Attendance records will not be collected but regular attendance of lectures is considered essential for satisfactory understanding of the material. All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences pre-approved by the UA Dean of Students (or Dean designee) will be honored. Make up exams will only be allowed in cases of well-documented emergencies, with approval of the instructor. Make up exams will be modified from the original and given as close to the exam date as possible.

Classroom Behavior and Classroom Policies Regarding Effective Learning:

Students are expected to adhere to the Code of Academic Integrity. The policies related to such issues as cheating and plagiarism will be strictly enforced. Read the full Code at: http://deanofstudents.arizona.edu/codeofacademicintegrity
In addition, individuals in groups can learn best when all are considerate of each other. Therefore, we ask that you please make every effort to make the environment in the classroom conducive to effective learning. This includes such things as turning off your cell phone, only using your laptop for class related activities, refraining from conversation that is not geared toward the topic of the day, arriving on time, and leaving when class is finished. Read the full Student Code of Conduct at:
http://deanofstudents.arizona.edu/policiesandcodes/studentcodeofconduct

Students with Disabilities

If you anticipate barriers related to the format or requirements of this course, please meet with the instructor so that we can discuss ways to ensure your full participation in the course. If you determine that disability-related accommodations are necessary, please register with Disability Resources (621-3268; drc.arizona.edu) and notify the instructor of your eligibility for reasonable accommodations. We can then plan how best to coordinate your accommodations.

Student Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity. See: http://deanofstudents.arizona.edu/tipsforavoidingacademicdishonesty

Threatening behavior policy

The University seeks to promote a safe environment where students and employees may participate in the educational process without compromising their health, safety, or welfare. The Arizona Board of Regents (ABOR) Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self. Threatening behavior can harm and disrupt the University, its community, and its families. Details on the policy can be found here:
https://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students

Nondiscrimination and Anti-harassment policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex (including pregnancy), national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. The University encourages anyone who believes they have been the subject of discrimination to report

the matter immediately as described in the section below, "Reporting Discrimination, Harassment, or Retaliation." All members of the University community are responsible for participating in creating a campus environment free from all forms of prohibited discrimination and for cooperating with University officials who investigate allegations of policy violations. Details on the policy can be found here:
https://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Confidentiality of Student Records
http://www.registrar.arizona.edu/ferpa/default.htm

Diversity, Equity, Inclusion and Mental Health Resources
Diversity is essential. It unites and moves us forward. The diverse perspectives that students and teaching team members bring to this class are a resource, strengths, and benefits. Others may have a different perspective and will bring a new focus to an issue. It is important to learn from the information and ideas shared by other students. To learn more about the UA's commitment to diversity and inclusion visit diversity.arizona.edu

Ideally science would be objective. However, as you will learn in this course, some of science is subjective and is historically built on a small subset of privileged voices. It is important to make note of this and think about how significant research findings may be biased by their nature of being carried out on a typically small, non-representative sample of human participants or animals.
Many resources are available to you, including:
Gender Pronouns: lgbtq.arizona.edu/use-chosen-or-preferred-names
Land Acknowledgment: nasa.arizona.edu
Commitment to Wellness: health.arizona.edu
Student service members and veterans: vets.arizona.edu
Basic Needs Statement: basicneeds.arizona.edu

Use of AI: In this course any and all uses of generative artificial intelligence (AI)/large language model tools such as ChatGPT, Dall-e, Google Bard, Microsoft Bing, etc. will be considered a violation of the Code of Academic Integrity, specifically the prohibition against submitting work that is not your own. This applies to all assessments in the course, including case studies, written assignments, discussions, quizzes, exams, and problem sets. This course policy is driven by the learning goals and desired learning outcomes for the course as described in this document.
The following actions are prohibited:
- entering all or any part of an assignment statement or test questions as part of a prompt to a large language model AI tool;
- incorporating any part of an AI-written response in an assignment;
- using AI to summarize or contextualize reading assignments or source materials; and
- submitting your own work for this class to a large language model AI tool for iteration or Improvement

Subject to Change Statement
Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor. Changes to the syllabus will be announced in class and posted on the class website.