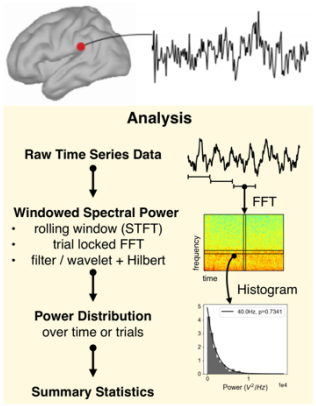
COGS118C – Neural Signal Processing (2019 Summer Session 1)

Instructor: Richard Gao (rigao@ucsd.edu)



• Are you excited by the notion of controlling an exoskeleton with your brain signals?
• Are you curious about the scientific pursuit of dissecting the neural basis of our minds?
• Are you driven by creating consumer neurofeedback technologies that can improve our lives?
• Or are you simply fascinated with decoding the brain as an extremely complex electrochemical system?

Learning how to analyze brain signals, as well as understanding their biological origins, are the first steps to accomplishing all of the above, and if you answered yes to any of those questions, you should consider enrolling in COGS118C - Neural Signal Processing, now offered in Summer Session 1.

Course Objectives

The overarching goal of this course is to prepare advanced undergraduate students for graduate studies and industry careers in (computational) neuroscience. Specifically, by the end of the course, students should leave with:

1) knowledge of cellular and physiological processed involved in various neural signals (from action potentials to EEG),

2) theoretical & mathematical understanding of signal processing algorithms,

3) a personal portfolio of Python programming toolbox that demonstrates practical proficiency in neural signal processing, and

4) reading and communication skills to critique and present scientific findings centered on articles in neuroscience.

Course Content

This course will cover theoretical foundations and practical applications of signal processing to neural data. Topics include EEG/field potential methods (time-frequency analysis, filtering, Fourier (spectral) analysis, coherence) and spike train analysis (reverse correlation, spike sorting, multi-electrode recordings). Some applications to neural imaging (optical microscopy, fMRI) data will also be discussed. In addition, there will be broad exposure to decomposition (PCA, ICA) and nonlinear techniques (nonlinear dynamical systems, neural network based), as well as state-of-the-art methods from current computational neuroscience. These methods are also broadly applicable to any point process and time-series data, such as sound waves (speech, music) and stock market fluctuations.

Course Schedule/Layout

Think of neural data analysis as designing a pipeline: from data collection to cleaning, processing, statistical analysis, and visualization. We will introduce a new component to the processing pipeline in each of the 5 weeks. By the end of the course, you will have programmed your own neural data analysis pipeline in Python, which you will use for a final project on a topic of your choice. You will also have an option to record your own EEG, or work with one of many publically available datasets from current neuroscience literature, to use for testing your analysis. The 80-minute class time each day will be (roughly) divided into:

- lectures on the physiological or mathematical concept,
- group discussions on the particular topic, or a scientific paper, and
- labs/coding time for exploring the concept in Python and work on your own project.

Recommended Prerequisites

Mathematics 18, 20A/B or 31AH
Cognitive Science 14B or Psychology 60
Cognitive Science 18, 108, or 109, or Computer Science equivalent

While all core concepts will be introduced from scratch, a good grasp of college-level calculus and linear algebra, Python/MATLAB programming, as well as introductory neurobiology is recommended.
Prerequisite requirements can be waived by the instructor, as assessed on a case-by-case basis. In general, we do not discourage students from taking courses that interest them. However, given the tight pace of summer sessions and the integration of several advanced topics in this class, you will get much more out of it if you didn't start the course playing catch-up.

Detailed syllabus will be available in May 2019 for registered students.
If you have any questions, please fee free to email Richard @ rigao@ucsd.edu with the subject line **COGS118C Inquiry**.

Instructor Bio

Richard is a 5th year PhD student in Dr. Bradley Voytek's lab, specializing in developing methods for extracting information from a variety of neural data across different species, including humans, rodents, and brain organoids. Prior to starting his PhD, he majored in biomedical engineering and has worked for a year at InteraXon Inc, developing real-time consumer EEG technology for neurofeedback and mindfulness meditation. In addition to publishing his research in scientific journals, he also maintains a blog, writing about general neuroscience and tutorials on signal processing techniques:
www.rdgao.com/blog.