

EEP 598/CSEP 590: Neural Devices, Systems, and Computation

Description: In this projects-based course, students will be introduced to the system integration practices for neural-interfacing devices with a focus on application programming interface (API) design to support closed-loop neural systems. Students will be introduced to applications of neural-interfacing devices such as Brain Computer Interfaces (BCIs) and commercial neuromodulation medical devices such as Deep Brain Stimulation (DBS). With these applications in mind, projects will focus on the development and design of APIs to continuously communicate, stream and process neural data, and control device functionality in real-time. Through these projects and class lectures, students will learn about the qualities of neural signals, data preprocessing and signal processing techniques, classifier development using machine learning methods, principles of real-time closed-loop control, and computer engineering concepts related to the integration of hardware and software for neural systems.

Students are expected to have some previous experience in programming, though only basic familiarity is required. Class projects will be written in C#, so familiarity with C#, Java, or C++ is highly recommended. Machine learning concepts will be learned using Python via off-line post-hoc analysis; no previous experience is necessary. An Arduino will be used in course projects as a surrogate for a remotely connected real-time device running class-provided code. Students will be required to purchase an Arduino for the course (approximate cost is \$30).

Course Staff

Instructors

Jeffrey Herron, PhD

Assistant Professor, Neurological Surgery

Adjunct Assistant Professor, Electrical and Computer Engineering, Bioengineering, Computer Science and Engineering

Faculty, Graduate Program in Neuroscience

Office Hours: Online Thursdays 3-5 (zoom link will be provided) or by appointment.

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Rajesh Rao, PhD

Professor, Computer Science and Engineering

Adjunct Associate Professor, Electrical and Computer Engineering, Bioengineering

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Assistant Instructor

Ares Fisher, PhD

Postdoctoral Researcher, Computer Science and Engineering

Office Hours and Location: **TBD**

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Teaching Assistant

Cory Lam

Masters Student, Electrical and Computer Engineering

Office Hours and Location: **TBD**

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Grading:

Four projects will be assigned, each of which will be 25% of the course grade. Each project will have clear objectives and milestones which will need to be satisfied for full marks, though some projects will have opportunities for extra credit. In the case of an incomplete project, partial credit will be provided based on how many objectives were completed. For those who have an incomplete project, a code checkpoint will be provided for use in the following project, no penalty will be incurred for anyone making use of the check-point in subsequent projects. Late submissions will have a flat 20% penalty applied.

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Topics Covered

- Programming Interfaces
 - Application programming interface design and development practices
 - Serial Communication and Packetization
 - Basic parallelism and asynchronous programming: timers, events, threads
 - Data streaming and real-time processing of data
- Neuroscience and Medical Devices
 - Neural signals and data acquisition methods
 - Neural Interfaces: Brain computer interfaces and neuromodulation devices
 - Principles of bidirectional and closed-loop control
 - Relevant regulations and neuroethics
- Neural Data Processing
 - Time-domain processing: filtering, power-in-band, evoked-potentials, and local field potentials
 - Spectral and wavelet analysis of neural signals
 - Neural spike identification and sorting
- Machine Learning and Data Classification
 - Unsupervised learning methods: component analysis, clustering, predictive coding, neural networks
 - Supervised learning techniques for classifier development
 - Principles of training and testing
 - Off-line and on-line classification of data using ML-trained classifiers

Diversity and Inclusion

In an ideal world, science including the science of teaching and learning would be objective. However, much of science is subjective and is historically built on a small subset of privileged voices. Integrating a diverse set of experiences is important for better understanding and learning in engineering, as well as accomplishing our engineering objectives outside of the classroom. We welcome your perspectives on the way we approach science and engineering in this class including suggestions to improve the quality of class materials. We are committed to creating a learning environment for our students that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc.)

To help accomplish this: (a) If you have a name and/or set of pronouns that differ from those that appear in your official UW records, please let me know. (b) If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with me. If you prefer to speak with someone outside of the course, the Associate Dean of Diversity and Access in the College of Engineering is an excellent resource:

<https://www.engr.washington.edu/about/leadership>

Like many others, your instructors are still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to us about it.

Disability and Access:

Your experience in this class is important to us. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law. If you have arranged accommodations through Disability Resources for Students (DRS), please communicate those accommodations to me at your earliest convenience so we can discuss your needs and appropriate arrangements in this course. If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), contact DRS directly to set up an Access Plan. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between you, your instructor(s) and DRS. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law. Contact DRS at disability.uw.edu.

Safety:

Call SafeCampus at 206-685-7233 anytime – no matter where you work or study – to anonymously discuss safety and well-being concerns for yourself or others. SafeCampus's team of caring professionals will provide individualized support, while discussing short- and long-term solutions and connecting you with additional resources when requested.

Academic Misconduct:

The University takes academic integrity very seriously. Behaving with integrity is part of our responsibility to our shared learning community. If you're uncertain about if something is academic misconduct, ask me. Engineering is a profession that demands a high level of personal honesty, integrity and responsibility. Therefore, it is essential that engineering students, in fulfillment of their academic requirements and in preparation to enter the engineering profession, adhere to the University of Washington's Student Code of Conduct (<https://www.washington.edu/cssc/for-students/student-code-of-conduct/>). Concerns about behaviors prohibited by the Student Conduct Code will be referred for investigation and adjudication by the College of Engineering Dean's Office and the University's Office of Community Standards and Student conduct.

See CoE website (<https://www.engr.washington.edu/mycoe/academic/integrity>) for a more detailed explanation of the academic misconduct adjudication process. Any student found to have committed academic misconduct will receive a 0-grade on impacted academic work (e.g., assignments, project, or exams).

Religious Accommodation:

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy:

<https://registrar.washington.edu/staffandfaculty/religiousaccommodations-policy/>

Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form:

<https://registrar.washington.edu/students/religiousaccommodations-request/>