EE 385J, Brain-Computer Interaction

Fall 2024

Hours: Monday & Wednesday, 15h00-16h30. GLT 1.106

Canvas Site: https://utexas.instructure.com/courses/1394829

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Office hours: 16h30-17h30, Monday & Wednesday; or by appointment.
Teaching Assistant, Office, Hours: Deland Liu, TBD.

Prerequisites: Graduate standing. Knowledge of Pattern Recognition/Machine Learning; Signal Processing; Matlab Programming (or any other equivalent Programming Language).

Course Description: This course examines how to provide a direct interaction between the human neural system and machines aiming to augment human capabilities, especially of disabled people. It provides an introduction to the human brain functional organization. It describes different brain signals that can be recorded for a brain-computer interface along with the interaction paradigms where they can be decoded and exploited. Emphasis is on electroencephalogram (EEG) signals, which is the most common source for brain-computer interfaces and the kind of signals used for the homework and projects. It also covers the design principles of complex brain-controlled devices beyond recording brain signals, enhancing their signal-to-noise ratio, and decoding subjects' intents and cognitive states.

Text:(1) Lecture Notes, taken from a variety of sources, available on the Canvas website.
(2) There is no mandatory textbook for the course. However, these two books provide supplementary material:

Wolpaw J. and Wolpaw E.W. (eds.) (2012). Brain-Computer Interfaces: Principles and Practice. Oxford University Press.

Ramsey N.F. and Millán J.d.R. (eds.) (2020). Brain-Computer Interfaces. Handbook of Clinical Neurology Series. San Diego: Elsevier.

Grading Scheme: Homework 25% + Paper Presentation: 15% + Term Project 60%.
Each item will be graded in the scale 1-10.
Attendance at all classes is expected, but not part of the grade.
Late submissions will not be accepted except by consent of instructor.

Homework: 3 individual exercises across the course based on data from BCI experiments. Discussion of homework questions amongst students is encouraged. However, copying another's work is cheating. Academic integrity is paramount and cheating will not be tolerated (see below).

Term Project: teams of 3 students will perform their own BCI experiments involving all team members over a few experimental sessions. Some lecture slots (2-4) during the course will be devoted to discussing progress and problems on the projects.
Timing: presentation, 15 min; Q&A, 10 min.
Grading: written report (35%); oral presentation to the whole class (25%).

Report must contain a statement of work done by each team member, indicating each member's contribution (i.e., topics and percentage of total effort).

Paper Presentation: same teams of 3 students will present a paper to the whole class (from a set of 2-3 topics) and critique another team's presentation on another paper of the same topic.
Timing: presentation, 15 min; critique, 5 min; discussion, 5 min.
Grading: presentation, 10%; critique, 5 %.

Letter Grades: In this course, plus and minus letter grades will be assigned.

Topical Outline

1. Overview of a Brain-Computer Interface
2. Short Tutorials on EEG Signal Processing & Machine Learning
3. Basic Human Brain Functional Organization
4. EEG & Inverse Methods
5. EEG-based BCI Paradigms
6. Multiunit Recordings, Local Field Potentials, Electrocorticogram
7. Cognitive Signals for Brain-Computer Interaction
8. Brain-Computer Interaction: Beyond Decoding
9. Term Projects: Oral Presentations

Learning Outcomes: By the end of the course, students will be able to

1. Students will be able to work effectively with peers to achieve common goals by collaborating on projects and sharing their opinions.
2. Students will be able to demonstrate proactive inquiry and exploration by asking thoughtful questions and seeking out additional information beyond the material covered in the class.
3. Students will be able to exhibit analytical thinking by breaking down complex problems into smaller components, evaluating evidence objectively, and drawing well-reasoned conclusions.
4. Students will be able to analyze critically scientific literature by identifying strengths and shortcomings of existing methods.
5. Students will be able to manage a team project by prioritizing tasks effectively, set realistic goals, and meet deadlines.
6. Students will be able to effectively communicate their work by reporting experiments, hypotheses, methods, and analyses succinctly in oral and written form.
7. Students will be able to demonstrate good experimental practice by conducting human experiments and recording participants' EEG.
8. Students will be able to demonstrate proficiency in deploying digital signal processing and machine learning methods by applying them to analyze EEG data.
9. Students will be able to interpret and analyze experimental data effectively by applying appropriate statistical methods, generating meaningful graphs, and drawing well-founded conclusions that contribute to a comprehensive understanding of the phenomena under investigation.

Grade Disputes or Corrections: If you discover an error in a grade assigned to you, you must submit your complaint, along with supporting evidence or arguments, to me (or to your TA or grader) within one week of the date that I (or your TA or grader) first attempted to return

the assignment results to you. Complaints about grades received after the one-week deadline will be considered only if there are extraordinary circumstances for missing the deadline. Assignments submitted for re-grading will be completely re-graded.

Academic Integrity: Plagiarism or any form of academic dishonesty (cheating includes, but is not limited to, copying another student's work, stealing another student's homework, bringing notes into a test and copying material directly from a book, article or web site without including appropriate references, falsifying data, doing someone's work) is a violation of University rules and may return a grade of zero for each assignment in which it is detected or may incur even steeper penalties. For more information and University policies please see: http://deanofstudents.utexas.edu/conduct/academicintegrity.php

Sharing of Course Materials is Prohibited: No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings: Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

Learning and Growth: Throughout the course, your learning and growth in theory and practice of the engineering profession are important to me. We all need accommodations because we all learn differently, and the current pandemic makes accommodations all the more important. If there are aspects of this course that prevent you from learning or exclude you, please let me know as soon as possible. Together we will develop strategies to meet your needs and course requirements. I also encourage you to reach out to the resources available through UT. Many are on this syllabus. I am happy to connect you with a person or Center if you would like.

Artificial Intelligence: The creation of artificial intelligence tools for widespread use is an exciting innovation. These tools have both appropriate and inappropriate uses in classwork. The use of artificial intelligence tools (such as ChatGPT) in this class is permitted for students who wish to use them, provided the content generated by AI is properly cited. AI writing tools should be used with caution and proper citation, as the use of AI should be properly attributed. Failing to properly cite AI even where permitted, shall constitute a violation of UT Austin's Institutional Rules on academic integrity. If you are considering the use of AI writing tools but are unsure if you are allowed or the extent to which they may be utilized appropriately, please ask.

Student Rights and Responsibilities:

- You have a right to a learning environment that supports mental and physical wellness.
- You have a right to respect.

- You have a right to be assessed and graded fairly.
- You have a right to freedom of opinion and expression.
- You have a right to privacy and confidentiality.
- You have a right to meaningful and equal participation, to self-organize groups to improve your learning environment.
- You have a right to learn in an environment that is welcoming to all people. No student shall be isolated, excluded or diminished in any way.

With these rights come responsibilities:

- You are responsible for taking care of yourself, managing your time, and communicating with the teaching team and others if things start to feel out of control or overwhelming.
- You are responsible for acting in a way that is worthy of respect and always respectful of others.
- Your experience with this course is directly related to the quality of the energy that you bring to it, and your energy shapes the quality of your peers' experiences.
- You are responsible for creating an inclusive environment and for speaking up when someone is excluded.
- You are responsible for holding yourself accountable to these standards, holding each other to these standards, and holding the teaching team accountable as well.

Personal Pronoun Use: Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender expression, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name, unless they have added a ``preferred name" with the Gender and Sexuality Center. Canvas provides an opportunity to select a pronoun preference. I will gladly honor your request to address you by a name that is different from what is on the roster, and by the gender pronouns you use (she/he/they/ze, etc).

Official Correspondence: The University of Texas at Austin considers e-mail as an official mode of university correspondence: https://cio.utexas.edu/policies/university-electronic-mail-student-notification-policy. You are responsible for following course-related information on the Canvas site for the course.

Students with Disabilities: The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Services for Students with Disabilities at 512-471-6259 or email ssd@austin.utexas.edu or check the website at http://ddce.utexas.edu/disability.

Religious Holidays: By University policy, students must notify instructor of pending absence at least fourteen days prior to the date of observance of a religious holy day. If a student must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, the student will be given an opportunity to complete the missed work within a reasonable time after the absence.

Absence for Military Service: In accordance with section 51.9111 of the Texas Education Code, a student is excused from attending classes or engaging in other required activities, including exams, if he or she is called to active military service of a reasonably brief duration. The maximum time for which the student may be excused has been defined by

the Texas Higher Education Coordinating Board as ``no more than 25 percent of the total number of class meetings or the contact hour equivalent (not including the final examination period) for the specific course or courses in which the student is currently enrolled at the beginning of the period of active military service." The student will be allowed a reasonable time after the absence to complete assignments and take exams.

Mental Health Counseling: College can be stressful and sometimes we need a little help. Luckily, we have a wealth of resources and dedicated people ready to assist you, and treatment does work. The Counseling and Mental Health Center (CMHC) provides counseling, psychiatric, consultation, and prevention services that facilitate student academic and life goals and enhance their personal growth and well-being. CMHC counselors are available Monday-Friday 8am-5pm by phone (512-471-3515) and Zoom videoconference. They are no longer available for in-person meetings due to social spacing and other precautions to reduce exposure to the coronavirus.

Alternatively, you can talk to Ms. Jeni Wade, LCSW right here in the College of Engineering. Ms. Wade is our Care Counselor and she can be reached at 512-471-8396.

If you are experiencing a mental health crisis (e.g. depression or anxiety), please call the Mental Health Center Crisis line at 512-471-CALL(2255). Call even if you aren't sure you're in a full-blown crisis, but sincerely need help. Staff are there to help you.

A wonderful resource is the MindBody Lab, a self-paced environment designed to help UT students explore various resources for improving their emotional and physical health. The Lab currently features audio and video instruction on a variety of topics, including sleep issues; food and body image; health and well-being; relaxation and meditation. Most of the material is experiential, enabling students to follow along and practice the skills as they are being discussed. MindBody Labs are located in SSB 5th floor, SAC 2.106 and NUR 3.156D.

Safety Information: If you have concerns about the safety or behavior of students, TAs, Professors, or others, call the Behavorial Concerns Advice Line at 512-232-5050. Your call can be anonymous. If something doesn't feel right, it probably isn't. Trust your instincts and share your concerns.

Occupants of buildings are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside.

For more information, please see http://www.utexas.edu/safety.

Title IX Reporting: Title IX is a federal law that protects against sex and gender-based discrimination, sexual harassment, sexual assault, sexual misconduct, dating/domestic violence and stalking at federally funded educational institutions. UT Austin is committed to fostering a learning and working environment free from discrimination in all its forms where all students, faculty, and staff can learn, work, and thrive. When sexual misconduct occurs in our community, the university can:

1. Intervene to prevent harmful behavior from continuing or escalating.
2. Provide support and remedies to students and employees who have experienced harm or have become involved in a Title IX investigation.
3. Investigate and discipline violations of the university's relevant policies.

Faculty members and certain staff members are considered ``Responsible Employees" or ``Mandatory Reporters," which means that they are required to report violations of Title IX to the Title IX Coordinator at UT Austin. Before talking with me, or with any faculty or staff member about a Title IX related incident, be sure to ask whether they are a responsible employee. If you want to speak with someone for support or remedies without making an official report to the university, email advocate@austin.utexas.edu. For more info about reporting options and resources, visit https://titleix.utexas.edu/campus-resources or contact the Title IX Office at titleix@austin.utexas.edu.

Land Acknowledgment: I would like to acknowledge that we are meeting on the Indigenous lands of Turtle Island, the ancestral name for what now is called North America. Moreover, I would like to acknowledge the Alabama-Coushatta, Caddo, Carrizo/Comecrudo, Coahuiltecan, Comanche, Kickapoo, Lipan Apache, Tonkawa and Ysleta Del Sur Pueblo, and all the American Indian and Indigenous Peoples and communities who have been or have become a part of these lands and territories in Texas.

References: This course syllabus uses wording suggested by Prof. Brian Evans, Prof. Mary Steinhardt and the Faculty Innovation Center (https://facultyinnovate.utexas.edu/effective-syllabus) at UT Austin. The above Land Acknowledgment was drafted by a faculty Committee on Land Acknowledgment and passed by the UT Austin Faculty Council on September 21, 2020.