Syllabus for ELE 594
Brain-Computer Interfaces (3.0 credit hours)
University of Rhode Island
Department of Electrical, Computer and Biomedical Engineering
Fall 2017

Instructor: Yalda Shahriari, Ph.D.
Phone: 401-874-5368
Office Hours: 1 pm - 2 pm, TW
Office location: Room 42, URI at Schneider Electric Building
Class Time: 5:00 pm – 7:45 pm, W
Class location: Bliss Hall 211
Email: Yalda_shahriari@uri.edu

Course Description: The possibility of transferring the brain signal to a computer device introduces many communication and control applications in both research and clinical domains. Within past several decades a new emerging technique, called brain-computer interface (BCI), has opened new channels to better understanding the brain functions, and facilitated techniques that can be used for the diagnosis and treatment of a wide range of neurological impairments. This course presents novel interfaces between brain and computer devices and explains the existing challenges in this domain. Through this course, different components of a BCI system including signal acquisition, signal preprocessing, feature extraction, and feature translation will be discussed. Conceptual and mathematical techniques to decode and encode the neural signals including spatial and temporal filtering, independent component analysis (ICA), principal component analysis (PCA), mutual information (MI), common spatial pattern (CSP), wavelet transform, Bayes classifier, and linear discriminant analysis (LDA) will be covered. Practical experiments on brain signal recording, the design of appropriate BCI experimental setup, and the implementable neural signal processing and classification approaches will also be covered.

Textbook: "Brain-Computer Interfaces" by Jonathan R. Wolpaw and Elizabeth Winter Wolpaw and "Analyzing Neural Time Series Data" by Mike X. Cohen are required as your textbook. The book by Dr. Wolpaw gives necessary BCI concepts and introduces the prominent challenges in this domain. The book by Dr. Cohen explains the most common techniques used in analyzing neural time series. This book also gives useful Matlab exercises which helps the reader get familiar with practical analysis of neural data.

Recommended Materials: As additional resources "Independent Component Analysis" by Aapo Hyvarinen, Juha Karhunen, and Erkki Oja is recommended. This book covers the basic concepts behind the random process and mathematical preliminaries which are necessary for various types of signal processing techniques including ICA. "Rhythms of the Brain" by György Buzsáki is also recommended as another additional resource. This book is beneficial for a better understanding the brain mechanisms at both structural and functional levels.

Course Prerequisites: The required background for the students majoring in Electrical, Computer, and Biomedical Engineering (ECBE) is the graduate standing. For the non-ECBE graduate students, the required background is three semesters of college level calculus, probability and statistics, signal processing, or the permission of the instructors. Familiarity with Matlab programming is also required.

Assessment and Grading Policy: Grading will be based on:

Homework and assignments (30%)
Exam (25%)
Final project, term paper, and presentation (45%; final project and term paper (%35), final presentation (10%))

Final grades will be assigned as below:

A	94-100%	**B+**	87-89%	**C+**	77-79%	**D+**	67-69%	**F**	< 60%
A-	90-93%	**B**	83-86%	**C**	73-76%	**D**	60-66%		
		B-	80-82%	**C-**	70-72%				

Topics to be covered (subject to change if needed):

- Introduction to BCI systems
- Relevant neurophysiology of the brain
- Signal acquisition
- Signal pre-processing
- Artifact removal
- BCI experimental design
- Overview of time-domain brain signal analysis
- Frequency and time-frequency domain brain signal analysis
- Dimensionality reduction
- Spatial filtering
- Machine learning algorithms for BCI systems
- Connectivity analysis

Homework Policies: Students are supposed to read the assigned materials by the date the material will be covered in the class. Homework assignments will be given regularly.

Neatness and legibility are important factors in exam and homework. Also, for the exam, mark each page with your name and the page number on the bottom right corner (e.g. John Doe, page 1 of 4). In this way, all the student's rights will be preserved.

Consideration for the homework grades are based on the submissions and the effort students put to solve the problems. The deadline for submitting the homework, is due at the beginning of the following class for the hard copy submissions, 11:55 pm of the class day for the online submissions. Late homework submissions, will not be considered. All homework submissions should include the following information: title (e.g. Homework One, or Project title, etc.),

student's name, date. For the hard copy write down your name and the page number on the bottom right corner of each page as specified in the test policies.

Final Project: Each group of students (typically 3-4 members) pick a project in which they need to conduct experimental design and data recording. There will be a proposal due date that each team is expected to send a one-page proposal to describe how they want to pursue their projects. For the data analysis and depending on each individual team member's interest, they need to choose to focus on different parts of data analysis including signal pre-processing, signal processing, and machine learning algorithms. Part of the last several sessions of the course, will be devoted to students' project where the students have the chance to discuss their team projects and individual ideas, brain storm together, ask questions and discuss their problems together and with the instructor.

The final project report is expected to have 6 sections including: 1) Abstract, 2) Introduction and Background, 3) Materials and Methods, 4) Results, 5) Discussion/Summary, and 6) References.

The students are expected to report their final term paper project as a 4-page, 2-column, IEEE conference paper format in terms of font and appropriate reference style. You can follow this link as a template.

NOTE: All the online report submissions should be received by 11:55 pm of the due date.

Test Make-up Policy: There will be one exam. The exam should be taken during class time on the day specified. Make up exam will only be given if you have a valid URI excusable absence. However, advance notification is required for the missed exam.

Attendance Regulations: You are expected to attend the class and participate in all group discussions regarding the team projects. Generally, regular class participation and activity are positively correlated with the students' final grades.

Office Hours: You can stop by my office during the office hours if you have any question. If you must see me outside of my office hours, please make an appointment.

Calculators: Simple calculators that do basic mathematics, e.g. add, multiply, divide, etc., are allowed during exams. Programmable and advanced calculators are prohibited. The exam is closed book/note. Any tables or supporting material for questions will be provided.

Sakai: Selected course materials, lectures, announcements, assignments, etc. will be made available to all the students through Sakai. Each student has access to Sakai for posting their homework and seeing their grades. Each student can have access to Sakai through the following website: https://sakai.uri.edu/portal/.

Participation in Discussion Forums: A discussion forum has been created for this class's students. The students are highly encouraged to post their questions/problems on this forum and brain storm together. This allows students to help each other and provides a great dynamic environment for them to discuss their problems. Extra credit will be considered for those active

students in this forum regardless of whether they ask/answer questions. You may discuss the strategies and problems with your friends on this forum, but posting any final answer for homework directly on the forum is prohibited. If you have any question regarding Sakai including the forum, please refer to: http://helpdesk.uri.edu/.

Plagiarism Policy: If you are caught breaking the URI honor code, you could be given an F for the course. **Being a student of higher standards, you pledge to embody the principles of academic integrity.** You may work with other students on your homework assignments, and you are encouraged to discuss concepts, principles and methods with each other; however, you must prepare your own final submission unless a group solution is specifically called for. You are not to copy another student's homework. Collaboration among students is not permitted during examinations.

Accommodation Policy: Students with special needs or any documented disability (http://web.uri.edu/disability/documentation/), please contact the instructor at their earliest convenience to discuss reasonable accommodations. Students should also contact the URI Disability Services for Students' office for further assistance in providing appropriate services and accommodations.

Policy on Incomplete Grades: Incomplete grades can only be given if there is a documented precipitating situation, serious illness or accident that interferes you with completing the course.

Equality Policy: To follow the equality policy and fair treatment to all the students, please DO NOT come to the instructor with an unreasonable request, outside of URI graduate conditions, and ask for boosting your grade or giving an "I" as your final grade because you don't want your grade to be reported in your final transcript.

Extra Credit Policy: Extra credit is often given for learning endeavors beyond contemporary class work. Also, extra credit will be considered for those active students in the class forum regardless of whether they ask/answer questions.

Exams and Projects' Timelines:

One-page proposal submission: Oct 25th
Exam: ~ Late Nov
Final project package and term paper submission: Dec 6th
Students' project presentations: Dec 6th

Suggestions for Success:

- Attend the class and ask questions.
- Read the textbook, lectures, and stay on top of your assignments.
- Make a quick overview about the topics of each session before the beginning of each class to have a better understanding of the ongoing problems and concepts.
- Review course materials taught right after each session while you are still remembering the details.

- Commit to constant effort, study routine, hard work with having a sense of managing your time.
- Try to think critically, understand the concepts, and feed your improvement with enthusiasm.
- Improve your cognitive ability by constantly learning something new!

"The chief function of the body is to carry the brain around." — Thomas A. Edison