ELEC3810 Data Science for Neural Engineering (Fall 2023) Credits: 3

This is an introductory course for the application of data science in neural engineering. The course will introduce the fundamental principles of data science, the technologies, and implementations of probability and statistical estimation, as well as the modeling of several practical questions in neural engineering. The topics include probability, random variables, statistical detection and estimation, random process, structure and function of the nervous system, encoding and decoding, population coding, neural network, plasticity and learning, neural interfaces, and rehabilitation. Concepts from probability, random processes, and estimation will be introduced so that students can understand and implement real examples of neural engineering, and recognize the impact of the latest technologies.
The course will enhance the vision of the students and encourage them to work in future interdisciplinary research fields. Students are expected to obtain knowledge of data science and neuroscience, and hands-on experience through a project on brain machine interfaces.
This course has elements of computational neuroscience and their application in neural engineering, an important area in biomedical engineering, which fits students with CBE backgrounds. It also has elements of data science and application for neural engineering, Therefore, it also fits the students from ECE. Students registered under different codes will be treated identically with only one set of course content and assessment arrangement.

Prerequisite: (MATH2111 or MATH 2121) and MATH 2421, or BIEN 2310 or BIEN 3320

Grade is based on homework (20%), mid-term exam (30%) and final project (50%).
A tentative schedule is described as follows.

Week 1: Introduction

Week 2: Probability and Random Variables

Week 3: Statistical detection (MAP, MLE)

Week 4: Statistical estimation (Linear regression)

Week 5: Random Process

Week 6: Structure and Function of the Nervous System (review of basic knowledge of neural signals)

Week 7: Encoding and Decoding（Bayesian estimator）

Week 8: Population Coding（vector space)

Week 9: Neural Networks

Week 10: Supervised Learning

Week 11: Reinforcement Learning

Week 12: Neural Prosthesis and Rehabilitation

Week 13: Review and Neural Interface challenge (Preparation of final projects)

Grade is based on homework (20%), mid-term exam (30%) and final project (50%).

Textbook:

1. Gray, Robert M., and Lee D. Davisson. An introduction to statistical signal processing. Cambridge University Press, 2004.
2. Dayan P, Abbott L F. Theoretical neuroscience: computational and mathematical modelling of neural systems, Cambridge, MA, USA: MIT Press. 01 December 2001.

Reference:

1. Leon-Garcia Al., Probability, Statistics, and Random Processes for Electrical Engineering,. 3rd Edition, Pearson Prentice Hall, 2008.
2. Michael S. Gazzaniga, Richard B. Ivry, George R. Mangun, Cognitive neuroscience: the biology of the mind, 3rd ed,New York : W.W. Norton, 2009
3. Kandel E R, Schwartz J H, Jessell T M. Principles of Neural Science[J]. Ion channels, 2000, 4: 5.
4. Trappenberg T. Fundamentals of computational neuroscience[M]. OUP Oxford, 2009.
5. Akay, Metin, ed. Handbook of neural engineering. Vol. 21. John Wiley & Sons, 2007.
6. Sanchez J C, Principe J C. Brain–machine interface engineering[J]. Synthesis Lectures on Biomedical Engineering, 2007, 2(1): 1-234.