ELEC 4830 & BIEN 4310
Statistical Signal Analysis and Application in Neural Engineering

Tuesday and Thursday: 12:00PM-1:20PM
Venue: 6591(lift 31,32)
Instructor: Wang, Yiwen

Neural Engineering is one of the most exciting inter-disciplinary technologies to impact neuroscience and information science, computation, and robotics. With more understanding of the brain, the interpretation of the perception, action, and learning impacts the development of neural interfacing and the design of bio-inspired robots. The basic concept of statistical signal processing and analysis is a fundamental tool to understand neural coding, and finds applications in neural interfacing, neural prostheses, and neuromorphic brain-based robots. 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 inter-disciplinary research fields. Students are expected to obtain knowledge of statistical signal processing and neuroscience, and hands-on experience through a project on brain machine interfaces.
This course is mathematics-oriented. It requires basic knowledge of linear algebra, calculus, and probability. Familiarity with the programming language MATLAB is needed.

Prerequisite: MATH2111

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

Week 1: A brief history of statistical signal processing and neural engineering
Week 2: Probability
Week 3: Random variables, vectors, and processes
Week 4: Expectation and averages
Week 5: Cellular mechanisms and neuroanatomy
Week 6: Sensation, perception, and action
Week 7: Neural coding
Week 8: Neurons in neural network
Week 9: Plasticity and Leaning
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)

No class on Oct. 14.

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 modeling of neural systems, Cambridge, MA, USA: MIT Press. 01 December 2001.

Reference：

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