ELEC4830 Statistical Signal Analysis and Applications in Neural Engineering

Course Description

This is an introductory course on statistical signal processing and its applications in neural engineering. The course introduces the fundamentals of statistical signal processing, principles of neuroscience, and the technologies and implementations of neural engineering. The topics include probability, random variables, vectors and process, expectation, cellular mechanisms and neuroanatomy of the brain, neural coding theory, neural network models, plasticity and learning, neural interfaces and rehabilitation. *Prerequisite(s):* (BIEN 3320 OR MATH 2111) AND (ELEC 2600 OR ISOM 2500 OR LIFS 3150 OR MATH 2411)

List of Topics

Week 1: A brief history of statistical signal processing and neural engineering
Week 2: Probability
Week 3: Statistical detection and estimation
Week 4: Random process
Week 5: Cellular mechanisms and neuroanatomy
Week 6: Sensation, perception and action
Week 7: Neural coding
Week 8: Population coding
Week 9: Neurons in neural network
Week 10: Plasticity and Leaning
Week 11: Supervised Learning
Week 12: Reinforcement Learning
Week 13: Neural Prosthesis and Rehabilitation (Preparation of final projects)

Statement of Objectives/Outcomes

Upon successful completion of this course, students will be able to:

CO1 - Understand the basic concepts of probability, random processes, expectation and averages.

CO2 - Obtain a holistic view of neural engineering.

CO3 – Recognize the neuroanatomy and understand the basic functions.

CO4 - Comprehend fundamentals of basic neural coding theory and computation methods.

CO5 – Analyze neural data and implement on neutrally-controlled device/robot.

CO6 - Enhance the knowledge in neural engineering, signal processing and practical programming.

Textbook(s)

1. Alberto Leon-Garcia, *Probablity, Statistics and Random Process for Electrical Engineering*, Pearson Education, 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(s)

1. Gray, Robert M., and Lee D. Davisson. *An introduction to statistical signal processing*. Cambridge University Press, 2004.
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.

Relationship of Course to Program Outcomes:

Please refer to the Report Section 4.3.2 (iii).

Grading Scheme:

Homework	20%
Midterm Examination	30%
Writing Assignment	20%
Final Project	30%