Syllabus – EEE 598 "Bioelectronics of Cells and Systems" (Spring 2009)

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Office hours: Wed,Fri 10:45-11:45 or by email appointment

Course Description: The course covers the electrophysiology of biological structures from an engineering viewpoint. The basic mechanisms of ionic charge transport and signal transmission will be discussed within a multi-scale approach ranging from ionic permeation across molecular pores to the transmission of polarization waves in complex neuronal structures. An overview of data recording and elaboration techniques will be supplied and mathematical models of noise in bioelectrical signals will be treated as well. Both natural and man-made biomimetic structures will be discussed.

Course Format: Lectures

Grading Policy: A 90%+, B 80%+, C 60%+, Failure below 60%.
Weight: Assignments 20%, Midterm exam 40%, Project 40%.

Textbook: James Keener, James Sneyd: "Mathematical Physiology", Springer Series in Interdisciplinary Applied Mathematics, Vol. 8, Springer-Verlag, NY (1998). ISBN 0-387-98381-3

Additional Reading: Bert Sakmann and Erwin Neher, eds.: "Single-Channel Recording", 2nd edition, Kluwer Academic/Plenum Publishers, NY (1995). ISBN 0-306-44870-X.
References to review papers available at the ASU Noble library will be supplied during the lectures.

Project:

Each student should review the current literature on the topic treated by one of the listed papers and produce a report that will be evaluated based on the following criteria:

- general understanding of the topic
- identification of open problems and possible solutions
- completeness of bibliographic research
- clarity of presentation, technical literacy

The report must be structured (and written) as a journal paper and cannot be a summary of the suggested reading. The paper listed for each subject is just a starting point for the bibliographic research. Students are strongly encouraged to use the services of the library for their bibliographic research.

The dead-line for the reports is April 06, 2009. Late reports will not be accepted. The instructor will accept suggestions for additional projects.

Suggested Project Topics:

- Krishnamurthy, V.; Shin-Ho Chung, "Adaptive learning algorithms for Nernst potential and I-V curves in nerve cell membrane ion channels modeled as hidden Markov models," *Nanobioscience, IEEE Transactions on* , vol.2, no.4, pp. 266-278, Dec. 2003.
- Krishnamurthy, V.; Shin-Ho Chung, "Brownian dynamics Simulation for modeling ion permeation across bionanotubes," *Nanobioscience, IEEE Transactions on* , vol.4, no.1, pp. 102-111, March 2005.
- Spanias, Andreas; Goodnick, Stephen; Thornton, Trevor; Phillips, Steve; Wilk, Seth; Kwon, HoMin, "Signal Processing for Silicon Ion-Channel Sensors," *Signal Processing Applications for Public Security and Forensics, 2007. SAFE '07. IEEE Workshop on* , vol., no., pp.1-4, 11-13 April 2007.
- Whittington, R.H.; Giovangrandi, L.; Kovacs, G.T.A., "A closed-loop electrical stimulation system for cardiac cell cultures," *Biomedical Engineering, IEEE Transactions on* , vol.52, no.7, pp. 1261-1270, July 2005.
- Edward J. Vigmond; Clyde Clements, "Construction of a Computer Model to Investigate Sawtooth Effects in the Purkinje System," *Biomedical Engineering, IEEE Transactions on* , vol.54, no.3, pp.389-399, March 2007.
- Chicca, E.; Badoni, D.; Dante, V.; D'Andreagiovanni, M.; Salina, G.; Carota, L.; Fusi, S.; Del Giudice, P., "A VLSI recurrent network of integrate-and-fire neurons connected by plastic synapses with long-term memory," *Neural Networks, IEEE Transactions on* , vol.14, no.5, pp. 1297-1307, Sept. 2003.
- Joines, William T.; Blackman, Carl F.; Hollis, Mark A., "Broadening of the RF Power-Density Window for Calcium-ion Efflux from Brain Tissue," *Biomedical Engineering, IEEE Transactions on* , vol.BME-28, no.8, pp.568-573, Aug. 1981.
- Kameda, S.; Yagi, T., "An analog silicon retina with multichip configuration," *Neural Networks, IEEE Transactions on* , vol.17, no.1, pp. 197-210, Jan. 2006.
- Grech, I.; Micallef, J.; Vladimirova, T., "Silicon cochlea and its adaptation to spatial localisation," *Circuits, Devices and Systems, IEE Proceedings* - , vol.146, no.2, pp.70-76, Apr 1999

Schedule of Class:

1) Homeostasis (a).
2) Homeostasis (b).
3) Ion Channels (a).
4) Ion Channels (b).
5) Nanopores.
6) Noise in permeation currents.
7) Excitability(a).
8) Excitability(b).
9) Bursting Electrical Activity.
10) Intracellular Communication.
11) Electrical Flow in Neurons.
12) Ca2+ Waves.
13) Electrophysiology of Vision.
14) Electrophysiology of Hearing.