Syllabus

Course Description

BIOM5101/BMG5104/SYSC5307/ELG6307 Biological Signals
Modeling of neuromuscular biological signals, including subthreshold phenomena, active behaviour of cell membranes, and innervation processes. Measurement of biological signals, including electrode effects. Time domain, frequency domain, and adaptive filtering techniques for noise reduction.

Course Website

www.sce.carleton.ca/courses/biom-5101/f11

Instructor

Dr. Adrian Chan
www.sce.carleton.ca/faculty/chan

Note that email should be written from your Carleton (or uOttawa) email account and that you should check (or forward) email on your Carleton email account. Email from accounts other than your Carleton email account may not receive any response.

Office hours: TBD

Lectures and Problem Analysis Sessions

Lectures: Mondays 18:00 - 21:00 Location TBD

Textbooks

There are no mandatory textbooks for this course.

Webster JG, Medical Instrumentation: Application and Design, 4th Edition, Wiley & Sons, 2010.

Matthews G. G., Cellular Physiology of Nerve and Muscle, 4th Edition, Blackwell Publishing, 2003.

Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.

Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Rangayyan, R. M. Biomedical Signal Analysis – A Case-Study Approach, IEEE Press/Wiley, New York, NY, 2002.

Plonsey R, Bioelectric Phenomena, McGraw-Hill, New York, NY, 1969.

Basmajian J and DeLuca CJ, Muscles Alive: Their Functions Revealed by Electromyography, 5th Edition, Lippincott, Williams & Wilkins, 1985.

Marking Scheme

40% Assignments
30% Project
30% Final Exam

Notes

The final exam is for evaluation purposes only and will not be returned to students.

Students are expected to attend all lectures and lab periods as required. The Faculty of Engineering and Design requires students to have a conflict-free timetable, so requests to accommodate missed exams, assignment due dates, project milestones, etc., because of conflicts with other courses, jobs or vacation plans will not be considered.

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website.

Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website.

Students with disabilities requiring academic accommodations in this course must register with the Paul Menton Centre for Students with Disabilities for a formal evaluation of disability-related needs. Registered PMC students are required to contact the Centre, 613-520-6608, every term to ensure that I receive your Letter of Accommodation, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you require accommodation for your formally scheduled exam(s) in this course, please submit your request for accommodation to PMC by November 11th 2011 for Fall term (December exams).

You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://carleton.ca/equity/accommodation.

Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offence that will not be tolerated. Note that the person providing solutions to be copied is also committing an offence as they are an active participant in the plagiarism. The person copying and the person copied from will be reprimanded according to the regulations set by Carleton University. Please refer to the section on instructional offences in the Graduate Calendar for additional information

Every student should have a copy of our Health and Safety Manual. An electronic version of the manual can be found at www.sce.carleton.ca/courses/health-and-safety.pdf.

Last updated August 4, 2011

Course Outline

Week 1

Introduction (Basic terminology, Excitable cells, Resting membrane and action potentials)

- Matthews G. G., Cellular Physiology of Nerve and Muscle, 4th Edition, Blackwell Publishing, 2003.
- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.
- Webster JG, Medical Instrumentation: Application and Design, 3rd Edition, Wiley & Sons, 2009.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Resting Membrane Potential (Nernst equation)

- Matthews G. G., Cellular Physiology of Nerve and Muscle, 4th Edition, Blackwell Publishing, 2003.
- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Week 2

Resting Membrane Potential (GHK equation)

- Matthews G. G., Cellular Physiology of Nerve and Muscle, 4th Edition, Blackwell Publishing, 2003.
- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Cable Equation (Cable equation, Sub-threshold phenomena, Strength-duration relationship)

- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.

Laboratory visit

Week 3

Action Potentials (Space clamp, Voltage clamp, TTX/TEA blocking of ion channels, Parallel conductance model, Hodgkin-Huxley model, Patch clamp, Conduction velocity, Myelination)

- Matthews G. G., Cellular Physiology of Nerve and Muscle, 4th Edition, Blackwell Publishing, 2003.
- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Week 4

Double Dipole Model

Transmission Line Model

- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.

Volume Conductor

- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.

Week 5

Electroneurogram, Electrocardiogram, Electromyogram, Electroencephalogram

- Plonsey R and Malmivuo J, *Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York NY, 1995.
- Webster JG, Medical Instrumentation: Application and Design, 3rd Edition, Wiley & Sons, 2009.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Stochastic Processes (random variable, random processing, cumulative distribution function, probability density function, stationarity, ergodicity)

- Papoulis A, Pillai SU, Probability, random variables, and stochastic processes, McGraw Hill, 2002.

Week 6

Stochastic Processes (continued)

- Papoulis A, Pillai SU, Probability, random variables, and stochastic processes, McGraw Hill, 2002.

Week 7

Modeling of Innervations (renewal process, power spectrum of renewal process, power spectrum of action potential train)

- Brody G, Scott RN, Balasubramanian R, "A model for myoelectric signal generation", Medical and Biological Engineering, pp. 29 - 41, 1974.
- Pan ZS, Zhang Y, Parker PA, "Motor unit power spectrum and firing rate", Medical and Biological Engineering and Computing, pp. 14 - 18, 1989.
- Englehart KB, Parker PA, "Single motor unit myoelectric signal analysis with nonstationary data", IEEE Transactions of Biomedical Engineering, vol. 41, no. 2, 1994.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.
- Cox DR, Smith NL, "On the superposition of renewal processes", Biometrics, vol. 41, pp. 91-99.
- Lago P, Jones NB, "Effect of motor-unit firing time statistics on e.m.g. spectra", Medical and Biological Engineering and Computing, vol. 15, pp. 648-655, 1977.

Dispersion Effects (effect of innervation zone dispersion, power spectrum of motor unit action potential train)

- Zhang YT, Paker PA, Scott RN, "Modifications of the ME Signal power density spectrum", Proceedings of the IEEE EMBS, pp. 2198-2199, 1990. (equation 3a is perhaps wrong)
- Ma T, Zhang YT, "Effects of dispersion filtering at endplates on the power spectrum of myoelectric signals" Proceedings of the IEEE EMBS, pp 180-181, 2002.
- Lindstrom LH, Magnusson, "Interpretation of myoelectric power spectra: A model and its application", Proceedings of the IEEE, vol. 65, no. 5, 653-662, 1977.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.

Week 8

Neural communication channels (intergral pulse frequency modulator, power spectrum, signal-to-noise ratio)

- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.
- Bayly EJ, "Spectral analysis of pulse frequency modulation in the nervous system", IEEE Transactions on Biomedical Engineering, vol. BME-15, no. 4, pp. 257-265, 1968.
- Jones RW, Li CC, Meyer AU, Pinter RB, "Pulse modulation in physiological systems, phenomenological aspects", IRE Transactions on Biomedical Electronics, pp. 59-67, 1961.

Effect of Electrode Configuration (monopolar, bipolar, and double differential electrode configurations, electrode size)

- Koh TJ, Grabiner MD, "Evaluation of methods to minimize cross talk in surface electromyography", Journal of Biomechanics, vol. 26, supplementary, pp. 151-157, 1993.
- Helal JN, Bouissou P, “The spatial integration effect of surface electrode detecting myoelectric signal”. IEEE Transactions on Biomedical Engineering, vol. 39, no. 11, pp. 1161–1167, 1992
- Bhullar HK, Loudon GH, Fothergill JC, Jones NB. "Selective noninvasive electrode to study myoelectric signals", Medical and Biological Engineering and Computing, vol. 28, pp. 581-586, 1990.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.
- Lindstrom LH, Magnusson, "Interpretation of myoelectric power spectra: A model and its application", Proceedings of the IEEE, vol. 65, no. 5, 653-662, 1977.

Week 9

Biopotential Electrodes (half-cell potentials, overpotentials, polarizable/nonpolarizable electrodes, Warburg model, motion artifact)

- Webster JG, Medical Instrumentation: Application and Design, 3rd Edition, Wiley & Sons, 2009.
- Geddes LA, Baker LE, Principles of applied biomedical instrumentation, Wiley-Interscience, 1989.

Biopotential Amplifiers

- Webster JG, Medical Instrumentation: Application and Design, 3rd Edition, Wiley & Sons, 2009.
- Merletti R and Parker P, Electromyography: Physiology, Engineering, and Non-invasive Applications, John Wiley and Sons, 2004.
- Sedra AS, Smith KC, Microelectronic circuits, Oxford University Press, 1997.

Week 10

Random noise, structured noise, physiological interference

- Rangayyan, R. M. Biomedical Signal Analysis – A Case-Study Approach, IEEE Press/Wiley, New York, NY, 2002.

Week 11

Random noise, structured noise, physiological interference continued.

- Rangayyan, R. M. Biomedical Signal Analysis – A Case-Study Approach, IEEE Press/Wiley, New York, NY, 2002.

Week 12

Project Presentations

Week 13

Project Presentations

Last updated August 4, 2011