EECE 434 Biosignals and Systems (Winter 2014 Term 2)

Course Duration: Jan. 05, 2015 – Apr. 10, 2015

Course website:
http://www.ece.ubc.ca/~elec434
This password protected course website will serve as the main form of information exchange in this course. All class announcements, course lecture notes, homework assignments, solutions, and any other handouts will be made available through this website. *Please frequently visit this course website throughout the semester.*

Instructor:
Z. Jane Wang; KAIS 4015; Tel: 2-3229

Format:
Lecture (3h/week) (Tutorials will be included in lectures)
The course will include a special guest lecture (by a medical prof.) with the intent of illustrating examples of cutting edge biomedical signal processing research.

Grading:
Homework assignments: (20%);
MidTerm exam: (25%)
Final Exam (in-class written component + take-home Matlab project component): 45%
Literature understanding exercise (a 1-page summary of a research paper + a 10-min presentation): (10%)
Note*: The grading policy could be adjusted based on practice during the semester.*

Text:
No textbook will be required, since the lecture notes will combine contents from several books and recent research papers. However, students may find the following recommended textbooks as helpful:

1. Steven W. Smith. The Scientist and Engineer's Guide to Digital Signal Processing (copyright ©1997-1998 by Steven W. Smith) http://www.dspguide.com/pdfbook.htm
2. John G. PROAKIS, DIMITRIS MANOLAKIS. Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall. (ISBN: 0131873741)
3. Alan V. Oppenheim and Ronald W. Schafer, Discrete-Time Signal Processing, Prentice Hall, 3rd Edition, 2009. ISBN: 0131988425.
4. Kayvan Najarian, Robert Splinter, Biomedical Signal and Image Processing, Second Edition 2012, CRC Press, ISBN: 1439870330.
5. Willis J. Tompkins. Biomedical Digital Signal Processing. (Previously printed by Prentice Hall, New 07458).
   http://ecow2.engr.wisc.edu/courses/mod/resource/view.php?id=8309
6. OTHER BOOKS AND PAPERS (SEE THE LECTURE NOTES). E.g.

- Rangaraj M. Rangayyan. Biomedical Signal Analysis - A Case-Study Approach. John Wiley & Sons, 2002. (ISBN: 9780471208116)
- Eugene N. Bruce. Biomedical Signal Processing and Signal Modeling. John Wiley & Sons, 2000. (ISBN: 9780471345404)

Summary:
In this course we will focus on the basic concepts, methodologies and tools of biosignal processing. This course introduces basic digital signal processing theory in the context of biomedical applications. Major topics of interest include: Data acquisition, time and frequency domain analysis, analog and discrete filter design, sampling theory, time-dependent processing, introduction to Wavelet, linear prediction, random signals, biomedical system modeling, and stability analysis; introduction to nonlinear systems; and introduction to pattern recognition and classification.

All methods will be developed to address certain concerns on specific data sets in modalities such as EEG, speech signal, fMRI. The lectures will be accompanied by data analysis assignments using MATLAB. Students will explore the basics of biosignal processing and gain the hands-on experience with MATLAB® Signal Processing Toolbox by doing homework assignments and a term project.

Course Outline:

1. **Introduction and basics**
   - Introduction to DSP
   - Introduction to biomedical Signals (nature, examples)
   - The z-transform
2. **Data acquisition (Sampling and Reconstruction of Signals)**
   - Continuous-time (CT) and discrete-time (DT) signals
   - Sampling theorem; Sampling of bandpass signals
   - Quantization
   - A/D conversion; D/A conversion
3. **Discrete-Time Signals and Systems**
   - Digital filters; LTI systems
   - Description by difference equations
   - Causality and stability
   - Correlation
   - Frequency Analysis of Signals and Systems
4. **The Discrete Fourier Transform (DFT)**
   - DFT; properties of DFT; using DFT
5. **Digital Filter Design** (1 lecture)
   - General consideration and design rules;
   - Design of digital filter based on least-square method
   - Matlab implementation of FIR filter design
6. **Multirate digital signal processing**

- Decimation, interpolation
- sampling rate conversion
- Application of MSP: e.g. Quadrature mirror filters
- Introduction to Wavelet analysis (added material)

7. Random variables and stochastic processes
   - Random variables; probability density functions (PDFs)
   - Moments and Cumulants; Multivariate distributions
   - Averages; auto-correlation functions; cross-correlation functions
   - Estimation of parameters of random signals
   - Statistical independence and stochastic processes
   - **Linear prediction; Auto-regressive model**
   - **Matched and Wiener filter**
   - Nonlinear models of signals
   - Analysis of nonstationary signals
8. Examples of biomedical signal processing (with specific biomedical applications)
9. An introduction to pattern recognition and classification
   - Supervised and unsupervised learning
   - Simple classification models: Linear and quadratic discriminant analysis, KNN, perceptron, basic idea of SVM
   - Feature generation and selection for classification
   - Independent components analysis

Useful links:

1. Free DSP books on the Internet: http://www.dsprelated.com/showarticle/56.php
2. A reference textbook "Biomedical Digital Signal Processing" http://ecow.engr.wisc.edu/cgi-bin/get/bme/463/tompkins/biomedical/
3. Digital Signal Processing Tutorial, Notes, Downloads http://www.onesmartclick.com/engineering/digital-signal-processing.html
4. Matlab Tutorial: http://www.engin.umich.edu/group/ctm/

Course Policies

Academic Honesty: You are responsible for all academic honesty policies, including adhering to prescribed resources during in class evaluations and take-home evaluations. Violations will be referred for disciplinary action. Pleas of ignorance will not be considered.

Assignments and Exams: While collaboration and discussion is encouraged on homeworks, the submitted Matlab projects and all take-home assignment/squizzes must be individual work. Late take-home quizzes/assignments will be accepted, but will be penalized 30% per day late. Questions can be directed to the instructor during the tutorial or during office hours.

The last day of class will be Apr. 10, 2015. Also note that the final exam date is TBD, but examinations will be scheduled from Apr. 14, 2015 to Apr. 29, 2015.