THE UNIVERSITY OF BRITISH COLUMBIA

School of Kinesiology

Course Outline

Program: Kinesiology	**Term/Year:** Sept – Dec 2022
Course #: KIN 500, Section 001	**Course Title:** Introduction to data acquisition and signal processing in Kinesiology
Day/Time: Thursday, 9h-12h	**Location(s):** Osborne Gym G (125G2)
Instructor: Jean-Sébastien Blouin **Phone:** 604-827-3372 **Email:** jsblouin@mail.ubc.ca	
Course Site: https://canvas.ubc.ca/	

Course Description:

The focus of this course is to provide graduate students with the practical experience necessary for the acquisition and processing of data related to human movements. This course will cover modern approaches and techniques commonly used for wearable sensing and laboratory research applicable to diverse disciplines related to Kinesiology, including biomechanics, physiology, neuroscience, psychology, and motor learning. These approaches and techniques include (but are not limited to) sampling theory, acquisition of analog and digital data with wearable and laboratory-grade instruments, synchronization of data from multiple sources, analog and digital filters as well as common data analysis methods. It is assumed that students have an undergraduate background in Kinesiology or related field as well as basic linear algebra and computer skills. Emphasis is placed on hands-on laboratory skills, presentation skills and on the methodological aspects underlying the development of a research project.

Objectives:

1. Learn the fundamental theory, tools and approaches to acquire and process data associated with human movements.
2. Formalise and present conceptual ideas, methodological approaches and results on data acquisition/signal processing topics related to human movements.
3. Evaluate the application of data acquisition and processing approaches to specific situations and provide feedback to peers.
4. Develop and perform a research project for an in-depth learning of specific topics discussed in class related to the students' research interest.

Expectations:

Students are required to perform weekly laboratory activities and/or presentations on topics discussed in class. In addition, they need to prepare for the material to be discussed in the roundtable discussions through proposed readings.

Course Evaluation:

A. Weekly or bi-weekly presentations: 30%

Students will lead a 4-minute presentation on the data acquisition/processing approaches and techniques learned during the preceding week. During the term, students are encouraged to use at least once a less familiar software for data analysis (Matlab, Python, R, Julia or LabVIEW).

An important emphasis is placed on data visualization & illustration of the main concepts. Students are encouraged to use LibreOffice, GSuite or Powerpoint.

B. Leading weekly or bi-weekly seminars: 20%

Students will lead class discussions at least once during the term. These presentations will be performed in teams. They will be in charge of:

Presenting the main topics they were assigned for the week (30-45 mins),
Highlighting 3 to 5 important concepts to discuss with the group (the use of creative figures and videos is encouraged),
Lead a discussion on potential limitations/issues related to the readings

C. Presentation of Research Project: 40%

Date to be determined. A 15-minute oral presentation of their research project. Students will present their research project with a major emphasis on the data acquisition requirements and signal processing approaches necessary for interpreting the data.

An important emphasis is placed on data visualization & illustration of the main concepts. Students are encouraged to use LibreOffice, GSuite or Powerpoint.

C. Class participation: 10%

Active class participation is required for the good functioning of the course. Students will be graded based on their preparation of the assigned material and participation to in-class roundtable discussions.

This course is centered around the students' interests and human movement data acquisition/processing needs. Consequently, students will be able to use the equipment in their research lab as well as wearable or laboratory-grade instrumentation available in the School of Kinesiology Learning Centre for the hands-on component. Although we will cover the theory underlying data acquisition and analysis, we will focus on the applications of key data acquisition and analysis concepts critical for applications involving human movements.

Readings:

Readings will consist of book chapters and original research articles from peer-reviewed journals.

Each week, students will be assigned a set of readings. These readings are intended to provide a background overview of the themes and concepts and must be read in preparation for the seminars. Students will facilitate a roundtable discussion and presentation of the topics covered in the assigned readings.

For week 1, students must bring to class a paper that uses a signal processing technique or describe a data-related problem they intend to learn in this course.

Sample list of recommended readings (more may be added throughout the course as appropriate):

Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing
http://www.dspguide.com/pdfbook.htm

Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Elsevier 2007. 308 pages
https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos

Wallisch P, Lusignan M, Benayoun M, Baker TI, Disckey AS, Hatsopoulos NG. MatLab for Neuroscientists. An introduction to scientific computing in Matlab. Elsevier. 2009. 384 pages

Gribble P. Scientific Computing with MATLAB (2016). https://openlibra.com/en/book/download/scientifc-computing-with-matlab

LabVIEW Manuals and Help Guides
http://www.ni.com/pdf/manuals/320999e.pdf

Matlab Manuals and Help Guides
http://www.mathworks.com/help/matlab/index.html
http://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf
http://www.mathworks.com/help/pdf_doc/matlab/matlab_prog.pdf

Python Books, Help Guides and Tutorials
https://wiki.python.org/moin/BeginnersGuide
https://greenteapress.com/wp/think-python-2e/
https://greenteapress.com/wp/think-dsp/

Bendat JS, Piersol AG. Random data analysis and measurement procedures (3rd Ed). Wiley. 2000. 594 pages

Siegmund GP. The reflex response of human neck muscles to whiplash-like perturbations. Doctoral thesis, The University of British Columbia. 2001

Teasdale N, Bard C, Fleury M, Young DE, Proteau L. Determining Movement Onsets from Temporal Series Journal of Motor Behavior. 1993; 25(2):97-106. DOI:10.1080/00222895.1993.9941644

Van Boxtel GJ, Geraats LH, Van den Berg-Lenssen MM, Brunia CH. Detection of EMG onset in ERP research. Psychophysiology. 1993 Jul;30(4):405-412.

Hodges PW, Bui BH. A comparison of computer-based methods for the determination of onset of muscle contraction using electromyography. Electroencephalogr Clin Neurophysiol. 1996 Dec;101(6):511-519.

Gescheider GA. Psychophysics: The Fundamentals. Taylor & Francis. 1997. 435 pages

Halliday DM and Rosenberg JR. Time and frequency domain analysis of spike train and time series data (Chap 18). In Modern Techniques in Neuroscience Research. (Eds: Windhorst U & Johanson H). Springer. 1999.

Winter DA. Biomechanics and Motor Control of Human Movement. Wiley. 2009. 384 pages

Merfeld DM. Signal detection theory and vestibular thresholds: I. Basic theory and practical considerations. Exp

Brain Res. 2011 210(3-4):389-405. doi: 10.1007/s00221-011-2557-7.

Osborne TM, Lakie M. A novel planar tracking technology for physiological image analysis. J Neurosci Methods. 2011. 202(1):53-9. doi: 10.1016/j.jneumeth.2011.08.041.

Staude G, Wolf W (1999) Objective motor response onset detection in surface myoelectric signals. Med Eng Phys 21:449-467.

Staude GH (2001) Precise onset detection of human motor responses using a whitening filter and the log-likelihood-ratio test. IEEE Trans Biomed Eng 48:1292-1305.

Schedule

Week 1	Course Introduction Brief introduction. Presentation of software relevant for data analysis and presentation Students present a paper that uses a signal processing technique or describe a data-related problem they intend to learn from this course.
Week 2	Signal Processing overview and Introduction to Matlab, Python, R & LabVIEW Readings: Gribble P. Scientific Computing with MATLAB (2016). Chap 1 & 2. Wallisch P et al. Matlab for Neuroscientists. An introduction to scientific computing in Matlab. Chap 2. https://www.youtube.com/watch?v=7bnVx34yQf4 https://www.mathworks.com/learn/tutorials/matlab-onramp.html http://www.ni.com/getting-started/labview-basics/
Week 3	Sampling a continuous time signal and Introduction to analog & digital signals using wearable or laboratory-grade instruments Readings: Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 1 & 2 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos) Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 3 (pp 35-48) & 4. Matlab & Arduino https://www.youtube.com/c/ArduinoRoboticsLabVIEWSolidworks/search?query=matlab%20arduino https://www.youtube.com/watch?v=8NQ1h0gGgX8 https://www.youtube.com/watch?v=nOz3uTi20Jo LabVIEW http://www.ni.com/white-paper/52648/en/ http://www.ni.com/product-documentation/2835/en/
Week 4	Preliminary findings, Tutorial & Discussions on Sampling a continuous time signal and Introduction to analog & digital signals.
Week 5	Synchronization of data from different sources using wearable and/or laboratory-grade instruments Readings: Osborne TM, Lakie M. A novel planar tracking technology for physiological image analysis. J Neurosci Methods. 2011. 202(1):53-9. doi: 10.1016/j.jneumeth.2011.08.041. Abraham L, Kalakanis D. Synchronization Of Video Kinematic And Analog Biomechanical Data Using The Motion Analysis System. International Symposium on Biomechanics in Sports (1993) Wu J, Sun L, Jafari R. A wearable system for recognizing American sign language in real-time using IMU and surface EMG sensors. IEEE Journal of Biomedical and Health Informatics. Vol 20:5, 2016 http://www.ni.com/product-documentation/4322/en/ http://www.ni.com/tutorial/11549/en/ https://www.ni.com/en-ca/support/documentation/supplemental/10/synchronization-explained.html

Week 6	Data analysis, noise & signal averaging Readings: Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 3 & 4 Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 2 & 4.
Week 7	Continuous, discrete and Fast Fourier Transform. Brief overview of correlation in the time and frequency domains. Readings (recommended to read in order): Wallisch P et al. Matlab for Neuroscientists. An introduction to scientific computing in Matlab. Chap 7 & 10. Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 5-6-8-9-10 & 12. Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 5, 6, 7 & 8 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos)
Week 8	Preliminary findings, Tutorial & Discussions on Continuous, discrete and Fast Fourier Transform
Week 9	Introduction to filters & filter analysis: The RC circuit Readings: Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 10, 11, 12 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos) Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 3 (pp 48-58)
Week 10	Introduction to filters & filter analysis: Digital filters Readings: Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 13 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos) Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 14, 15, 16, 19, 20 & 21 (chapter 17 if interested).
Week 11	Preliminary findings, Tutorial & Discussions on Introduction to filters & filter analysis: Digital filters
Week 12	Research Project
Week 13	Research Project
Week 14	Research Project Presentations