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BIOM/ECE 537 Biomedical Signal Processing

Spring 2018

Lectures: MWF, 10AM-10:50AM, **Engineering B2**

Instructor: Jesse Wilson

Email: jesse.wilson@colostate.edu (<mailto:jesse.wilson@colostate.edu>)

Skype Messaging: jessew@colostate.edu (<mailto:jessew@colostate.edu>)

Phone: 970-491-3706

Office Hours: Wednesdays 12--2PM, Scott Building 324 or by appointment

MATLAB Grader Designer: Saurabh Gupta

Your feedback and input is always welcome! You have the opportunity to help shape this class for future students.

OVERVIEW: An in-depth course on modeling and classification of biosignals (e.g. EEG, ECG, EMG), covering adaptive filtering, wavelets, neural networks, and handling problems with overfitting of noisy data.

PREREQUISITES: MATH340 or ECE311 or STAT303

LEARNING OBJECTIVES: At the end of this course, successful students will be able to:

- Choose an appropriate model for biomedical signals
- Evaluate model fitting results and recognize overfitting
- Classify signals using fitted model parameters
- Predict future samples of a time series and estimate narrowband frequency components using autoregression.

CALENDAR**BIOM/ECE537 SP2020**

Today

Tuesday, January 28 ▼

 Print
 [Week](#)
[Month](#)
[Agenda](#) ▼
Wednesday, January 29

4. Linear classifier formalism

12:00pm [Office Hours](#)**Friday, January 31**

(No class today)

Monday, February 3

(No class today)

Wednesday, February 5

5. Digital filter review

12:00pm [Office Hours](#)**Friday, February 7**

6. FIR filtering as a matrix product

Monday, February 10

7. Wiener optimal filtering

Wednesday, February 12

8. Adaptive filtering

12:00pm [Office Hours](#)**Friday, February 14**

9. Adaptive filter applications

Monday, February 17

10. Fourier transform as a basis expansion

Wednesday, February 19

11. Other types of basis expansions

Events shown in time zone: Mountain Time - Denver

Calendar

REQUIRED TEXTBOOK:

- *Biosignal and Medical Image Processing*, 3rd ed. by J. Semmlow & B. Griffel, CRC Press Taylor & Francis Group, 2014. (Available at CSU bookstore)

OTHER REQUIRED MATERIALS:

- *The Elements of Statistical Learning*, 2nd, by Hastie, Tibshirani, and Friedman. Accessible online through <https://web.stanford.edu/~hastie/ElemStatLearn/> [\(https://web.stanford.edu/~hastie/ElemStatLearn/\)](https://web.stanford.edu/~hastie/ElemStatLearn/).
- *Fundamentals of Adaptive Signal Processing*, by Aurelio Uncini. Accessible online through CSU's library subscription at: <https://link.springer.com/book/10.1007%2F978-3-319-02807-1>. [\(https://link.springer.com/book/10.1007%2F978-3-319-02807-1\)](https://link.springer.com/book/10.1007%2F978-3-319-02807-1)
- MATLAB software. Available on any ENS lab computer, or remotely through the [ENS Virtual Classroom](#) [\(http://www.engr.colostate.edu/ens/tools/virtualclass/\)](http://www.engr.colostate.edu/ens/tools/virtualclass/).

Canvas: canvas.colostate.edu will have the syllabus, links, homework, course grades and other postings. It is your responsibility to check the calendar under the Index tab each week for new postings.

COURSE TOPICS: The planned topics for this course are:

Weeks 1-2	Intro to signal modeling & classification, model complexity, and overfitting.
Week 3-4	Optimal and adaptive filtering.
Week 5	Fourier series, basis expansions, intro to inverse problems and regu
Week 6	Review and exam
Week 7-8	Spectrograms, Wavelets: continuous, discrete, applications for denoising and feature extraction.
Week 9	Review and exam.
Weeks 10-11	Principal and independent component analysis. Dimension reduction.
Week 12-14	Exam on PCA/ICA. Neural networks and applications.
Week 15	Convolutional and deep neural networks.
Week 16	Final

GRADING [draft; to be finalized in the first week of classes]:

Quizzes (online and in-class): 20%. Lowest 3 scores will be dropped.

Homework assignments: 40%. Lowest 1 scores will be dropped.

Exams Exam: 20%

Final Project: 20%

The final exam date and location is TBD. Check with your instructor and Canvas for updates.

Final grades will be determined by the following scale:

A+ 100% to 96.67%

A < 96.67% to 93.33%

A- < 93.33% to 90%

B+ < 90% to 86.67%

B < 86.67% to 83.33%

B- < 83.33% to 80%

C+ < 80% to 76.67%

C < 76.67% to 70%

D < 70% to 60%

F < 60% to 0%

HOMEWORK:

Homework will be due one week after it is assigned, , but check the website for updates. Links to the homework can be found on Canvas. **All late assignments will receive a zero.**

Unless otherwise indicated, all homeworks for this class are to be completed online in MATLAB Grader (<https://grader.mathworks.com/> (<https://grader.mathworks.com/>)). You will need to sign up for a (free) Mathworks account linked to your CSU email address.

This is the first year for our use of MATLAB Grader. There may be bugs, and some of the tasks may be unclear. Get an early start and ask questions.

All submitted homework and code must be your own individual work. Since a large portion of the work will be writing MATLAB code, students are expected to adhere to the Academic Integrity Policies found on the Computer Science Department











website: http://www.cs.colostate.edu/cstop/csacademics/student_info.php
















(http://www.cs.colostate.edu/cstop/csacademics/student_info.php)
















ACADEMIC INTEGRITY: Students are expected to adhere to the Academic Integrity Policy of Colorado State University, outlined in the CSU General Catalog. Students are also expected to follow the Student Conduct Code which can be found at www.conflictresolution.colostate.edu. Academic dishonesty is not accepted in this course, and any form of cheating (including plagiarism) will be reported. Penalties may include a lowered course grade, loss of course credit, and expulsion from the university.
















ABSENCES, LATE ASSIGNMENTS: Students are expected to attend all lectures and complete all assignments on time. Late assignments will receive at most half credit. Extensions will be considered only for family/personal/medical emergencies, or official university business.









Course Summary:

Date	Details	
Thu Jan 23, 2020	 Lecture 01 summary (https://colostate.instructure.com/courses/95153/assignments/1106756)	due by 11:59pm
Sat Jan 25, 2020	 Lecture 02 summary (https://colostate.instructure.com/courses/95153/assignments/1123110)	due by 11:59pm
Mon Jan 27, 2020	 Correlation, covariance, and classification (https://colostate.instructure.com/courses/95153/assignments/1123897)	due by 11:59pm
Tue Jan 28, 2020	 Lecture 03 summary (https://colostate.instructure.com/courses/95153/assignments/1123112)	due by 11:59pm
Wed Jan 29, 2020	 Linear classifiers (https://colostate.instructure.com/courses/95153/assignments/1106813)	due by 11:59pm
Thu Jan 30, 2020	 Lecture 04 summary (https://colostate.instructure.com/courses/95153/assignments/1123113)	due by 11:59pm
	 Project preferences (https://colostate.instructure.com/courses/95153/assignments/1142458)	due by 11:59pm
Fri Jan 31, 2020	 HW00: MATLAB Onramp (optional) (https://colostate.instructure.com/courses/95153/assignments/1122878)	due by 11:59pm
Wed Feb 5, 2020	 Digital filters (https://colostate.instructure.com/courses/95153/assignments/1123925)	due by 11:59pm
Thu Feb 6, 2020	 Lecture 05 summary (https://colostate.instructure.com/courses/95153/assignments/1123114)	due by 11:59pm

Date	Details	due by 11:59pm
Fri Feb 7, 2020	 Convolution matrices (https://colostate.instructure.com/courses/95153/assignments/1123931)	due by 11:59pm
	 HW01: Linear classification (https://colostate.instructure.com/courses/95153/assignments/1106732)	due by 11:59pm
Sat Feb 8, 2020	 Lecture 06 summary (https://colostate.instructure.com/courses/95153/assignments/1123115)	due by 11:59pm
Mon Feb 10, 2020	 Optimal Signal Processing (https://colostate.instructure.com/courses/95153/assignments/1106817)	due by 11:59pm
Tue Feb 11, 2020	 Lecture 07 summary (https://colostate.instructure.com/courses/95153/assignments/1123117)	due by 11:59pm
Wed Feb 12, 2020	 Adaptive filtering (https://colostate.instructure.com/courses/95153/assignments/1106727)	due by 11:59pm
Thu Feb 13, 2020	 Lecture 08 summary (https://colostate.instructure.com/courses/95153/assignments/1123118)	due by 11:59pm
Fri Feb 14, 2020	 HW02: FIR filtering as convolution and matrix product (https://colostate.instructure.com/courses/95153/assignments/1106733)	due by 11:59pm
Sat Feb 15, 2020	 Lecture 09 summary (https://colostate.instructure.com/courses/95153/assignments/1123119)	due by 11:59pm
Mon Feb 17, 2020	 Fourier series (https://colostate.instructure.com/courses/95153/assignments/1123939)	due by 11:59pm
Tue Feb 18, 2020	 Lecture 10 summary (https://colostate.instructure.com/courses/95153/assignments/1123135)	due by 11:59pm
Thu Feb 20, 2020	 Lecture 11 summary (https://colostate.instructure.com/courses/95153/assignments/1123136)	due by 11:59pm
Fri Feb 21, 2020	 HW03: Weiner optimal filtering (https://colostate.instructure.com/courses/95153/assignments/1106726)	due by 11:59pm
Sat Feb 22, 2020	 Lecture 12 summary (https://colostate.instructure.com/courses/95153/assignments/1123137)	due by 11:59pm
Wed Feb 26, 2020	 Exam 1 (https://colostate.instructure.com/courses/95153/assignments/1106814)	due by 11:59pm

Date	Details	
Fri Feb 28, 2020	 HW04: Adaptive filtering (https://colostate.instructure.com/courses/95153/assignments/1106741)	due by 11:59pm
Mon Mar 2, 2020	 Spectrograms (https://colostate.instructure.com/courses/95153/assignments/1124009)	due by 11:59pm
Tue Mar 3, 2020	 Lecture 13 summary (https://colostate.instructure.com/courses/95153/assignments/1123138)	due by 11:59pm
Wed Mar 4, 2020	 Wavelets (https://colostate.instructure.com/courses/95153/assignments/1106821)	due by 11:59pm
Thu Mar 5, 2020	 Lecture 14 summary (https://colostate.instructure.com/courses/95153/assignments/1123146)	due by 11:59pm
Fri Mar 6, 2020	 HW05: Regularized basis projection (https://colostate.instructure.com/courses/95153/assignments/1106743)	due by 11:59pm
Sat Mar 7, 2020	 Lecture 15 summary (https://colostate.instructure.com/courses/95153/assignments/1123147)	due by 11:59pm
Mon Mar 9, 2020	 Wavelets 2 (https://colostate.instructure.com/courses/95153/assignments/1124011)	due by 11:59pm
Tue Mar 10, 2020	 Lecture 16 summary (https://colostate.instructure.com/courses/95153/assignments/1123148)	due by 11:59pm
Thu Mar 12, 2020	 Lecture 17 summary (https://colostate.instructure.com/courses/95153/assignments/1123149)	due by 11:59pm
Fri Mar 13, 2020	 HW06: Continuous Wavelets (https://colostate.instructure.com/courses/95153/assignments/1106745)	due by 11:59pm
Sat Mar 14, 2020	 Lecture 18 summary (https://colostate.instructure.com/courses/95153/assignments/1123150)	due by 11:59pm
Wed Mar 25, 2020	 Exam 2 (https://colostate.instructure.com/courses/95153/assignments/1123071)	due by 11:59pm
Fri Mar 27, 2020	 HW07: Wavelet denoising (https://colostate.instructure.com/courses/95153/assignments/1106747)	due by 11:59pm
	 PCA (https://colostate.instructure.com/courses/95153/assignments/1106818)	due by 11:59pm

Date	Details	due by 11:59pm
Sat Mar 28, 2020	 Lecture 19 summary (https://colostate.instructure.com/courses/95153/assignments/1123151)	due by 11:59pm
Tue Mar 31, 2020	 Lecture 20 summary (https://colostate.instructure.com/courses/95153/assignments/1123180)	due by 11:59pm
Wed Apr 1, 2020	 Independent Component Analysis (https://colostate.instructure.com/courses/95153/assignments/1106754)	due by 11:59pm
Thu Apr 2, 2020	 Lecture 21 summary (https://colostate.instructure.com/courses/95153/assignments/1123189)	due by 11:59pm
Fri Apr 3, 2020	 HW08: Principal Component Analysis (https://colostate.instructure.com/courses/95153/assignments/1106748)	due by 11:59pm
Sat Apr 4, 2020	 Lecture 22 summary (https://colostate.instructure.com/courses/95153/assignments/1123190)	due by 11:59pm
Tue Apr 7, 2020	 Lecture 23 summary (https://colostate.instructure.com/courses/95153/assignments/1123192)	due by 11:59pm
Thu Apr 9, 2020	 Lecture 24 summary (https://colostate.instructure.com/courses/95153/assignments/1123253)	due by 11:59pm
Fri Apr 10, 2020	 Neural networks (https://colostate.instructure.com/courses/95153/assignments/1124014)	due by 11:59pm
Sat Apr 11, 2020	 Lecture 25 summary (https://colostate.instructure.com/courses/95153/assignments/1123814)	due by 11:59pm
Tue Apr 14, 2020	 Lecture 26 summary (https://colostate.instructure.com/courses/95153/assignments/1123845)	due by 11:59pm
	 Lecture 27 summary (https://colostate.instructure.com/courses/95153/assignments/1123848)	due by 11:59pm
Fri Apr 17, 2020	 HW09: ICA (https://colostate.instructure.com/courses/95153/assignments/1106752)	due by 11:59pm
Mon Apr 20, 2020	 Exam 3 (https://colostate.instructure.com/courses/95153/assignments/1123075)	due by 11:59pm
Sat Apr 25, 2020	 Lecture 28 summary (https://colostate.instructure.com/courses/95153/assignments/1123850)	due by 11:59pm

Date	Details	
Tue Apr 28, 2020	 Lecture 29 summary (https://colostate.instructure.com/courses/95153/assignments/1123851)	due by 11:59pm
Thu Apr 30, 2020	 Lecture 30 summary (https://colostate.instructure.com/courses/95153/assignments/1123852)	due by 11:59pm
Fri May 1, 2020	 Convolutional networks (https://colostate.instructure.com/courses/95153/assignments/1124019)	due by 11:59pm
	 HW10: Neural net classifier (https://colostate.instructure.com/courses/95153/assignments/1122987)	due by 11:59pm
Sat May 2, 2020	 Lecture 31 summary (https://colostate.instructure.com/courses/95153/assignments/1123853)	due by 11:59pm
Tue May 5, 2020	 Lecture 32 summary (https://colostate.instructure.com/courses/95153/assignments/1123854)	due by 11:59pm
Fri May 8, 2020	 Exam 4 (https://colostate.instructure.com/courses/95153/assignments/1123081)	due by 11:59pm
Fri May 15, 2020	 Final (https://colostate.instructure.com/courses/95153/assignments/1106730)	due by 11:59pm