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Important information for students on COVID-19:

All students are required to follow public health guidelines in any university space, and are encouraged to continue these practices when off-campus(es). Students also are required to report any COVID-19 symptoms to the university immediately, as well as if they have potentially been exposed or have tested positive at a non-CSU testing location. If you suspect you have symptoms, please fill out the COVID Reporter (<https://covid.colostate.edu/reporter/> (<https://covid.colostate.edu/reporter/>)). If you have COVID symptoms or know or believe you have been exposed, it is important for the health of yourself and others that you complete the online COVID Reporter. Do not ask your instructor to report for you; if you report to your instructor that you will not attend class due to symptoms or a potential exposure, you are required to also submit those concerns through the COVID Reporter. If you do not have access to the internet to fill out the online COVID-19 Reporter, please call (970)491-4600.

If you report symptoms or a positive test, your report is submitted to CSU's Public Health Office. You will receive immediate, initial instructions on what to do and then you will also be contacted by phone by a public health official. Based on your specific circumstances, the public health official may:

- choose to recommend that you be tested and help arrange for a test
- conduct contact tracing
- initiate any necessary public health requirements or recommendations and notify you if you need to take any steps

If you report a potential exposure, the public health official will help you determine if you are at risk of contracting COVID.

For the latest information about the University's COVID resources and information, please visit the **CSU COVID-19 site** (<https://covidrecovery.colostate.edu/> (<https://covidrecovery.colostate.edu/>)).

BIOM/ECE 431 Biomedical Signal and Image Processing (BSIP)

Spring 2021

Lectures: ,

Lectures available live through MS Teams and recorded online through Echo360.

Instructor: Jesse Wilson

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

MS Teams: Wilson,Jesse

<mailto:jessew@colostate.edu> Phone: [Voice over MS Teams]

Office Hours: [MS Teams chat: jessew].

Lecture Time: 12:30-1:45 PM Tues/Thurs (**Synchronous attendance required**)

Location: **Scott 229** and MS Teams, according to [Phased Spring 2021 Schedule for Hybrid/Hyflex instruction](https://covid.colostate.edu/kb/phased-spring-2021-schedule/) [\(https://covid.colostate.edu/kb/phased-spring-2021-schedule/\)](https://covid.colostate.edu/kb/phased-spring-2021-schedule/).

- Jan 19-22 (Phase 1): live online via MS Teams (synchronous)
- Jan 25--Feb 5? (Phase 2): live online via MS Teams (synchronous)
- Feb 5? -- Spring Break: Lectures in person in ENGR B2 *and* live streaming via MS Teams.
- After Spring Break: Lectures live online via MS Teams (synchronous).
- Recordings will also be made available on Echo360, typically < 4 hours after live lecture.

Teaching Assistant: Kaitie Wood

MATLAB Grader Assignments Developers: Saurabh Gupta, Kaitie Wood

COURSE CALENDAR
BIOM/ECE431 SP2021

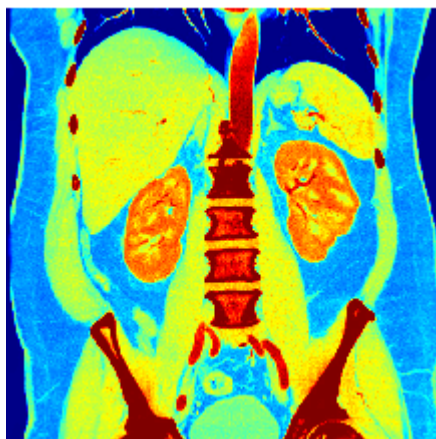
Today March 2021 Print Week Month Agenda

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	Mar 1	2 Project teamwork	3	4 11. ECG Abnorma	5 HW04.1 DUE (Ele	6
7	8 PRJ Feasibility re	9 12. ECG Signal P	10 PRJ Feasibility Pe	11 Exam 2: ECG and	12 HW05 DUE (ECG	13
14	15	16 13. Classification	17	18 Classification den	19 HW06 DUE (Class	20
21	22	23 Neural Nets	24	25 Exam 3: Classific	26 HW06b DUE (neu	27
28	29	30 14. Intro to imag	31	Apr 1 15. Image transf	2 HW07 DUE (imag	3

Events shown in time zone: Mountain Time - Denver

Calendar

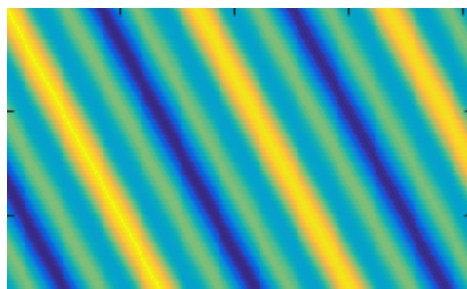
Your feedback and input is always welcome! You have the opportunity to help shape this class for future students.



False color rendering of a computed tomography slice.

COURSE OBJECTIVES: Upon completion of this class, students will:

- Define common biomedical signal and image terms including the acronyms ECG, EEG, EMG, MRI, PET and CT.
- Identify the physiological source of common biomedical signals and images.
- Recognize and describe unique primary features of common biomedical signals and images.
- Discuss typical sources of interference and noise and their impact on biomedical signals and images.
- Mathematically transform and filter biomedical signals and images to reduce the impact of interference and noise
- Quantitatively assess the quality of biomedical signals and images before and after processing.
- Employ computer aided engineering software, such as MATLAB, to beneficially process biomedical signals and images.
- Select appropriate signal and image processing methods to apply to example biomedical applications.



Adaptive filter Toeplitz matrix.

PREREQUISITES: PH 142, LIFE 210, ECE 311, ECE 303 (co-requisite)

REQUIRED MATERIALS:

- *Biosignal and Medical Image Processing*, 3rd ed. by J. Semmlow & B. Griffel, CRC Press Taylor & Francis Group, 2014. (Available at CSU bookstore). Data can be downloaded here: <https://www.crcpress.com/Biosignal-and-Medical-Image-Processing-Third-Edition/Semmlow-Griffel/p/book/9781466567368> [_ \(https://www.crcpress.com/Biosignal-and-Medical-Image-Processing-Third-Edition/Semmlow-Griffel/p/book/9781466567368\)_](https://www.crcpress.com/Biosignal-and-Medical-Image-Processing-Third-Edition/Semmlow-Griffel/p/book/9781466567368).
- *The Biomedical Engineering Handbook*, 2nd ed. Edited by J. D. Bronzino, CRC Press, 1999. Accessible online <http://www.crcnetbase.com/doi/book/10.1201/9781420049510> [_ \(http://www.crcnetbase.com/doi/book/10.1201/9781420049510\)](http://www.crcnetbase.com/doi/book/10.1201/9781420049510) from any campus computer through CSU library subscription.
- MATLAB software. Available on any ENS lab computer, or remotely through the [ENS Virtual Classroom](http://www.engr.colostate.edu/ens/tools/virtualclass/) [_ \(http://www.engr.colostate.edu/ens/tools/virtualclass/\)_](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 1-5	Signal processing toolkit: measurements, noise, spectral analysis, digital filters, MATLAB.
Weeks 6-8	Electrophysiology and electrocardiography (ECG).
Weeks 9-10	Feature extraction, dimension reduction, and classification.
Weeks 11-12	Image processing toolkit: transforms, 2DFFT, and filtering.
(SPRING BREAK)	
Week 13-14	Medical imaging: Microscopy, Computed Tomography, Positron Emission Tomography, Magnetic Resonance Imaging
FINALS	Group project reports due.

GRADING:

Quizzes (online): 20%

Homework assignments: 40%

Midterm Exam: 20%

Final Project: 20%

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



PET image of glucose uptake in the brain (from <http://jnm.snmjournals.org/content/45/4/594.abstract> (<http://jnm.snmjournals.org/content/45/4/594.abstract>)).

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%

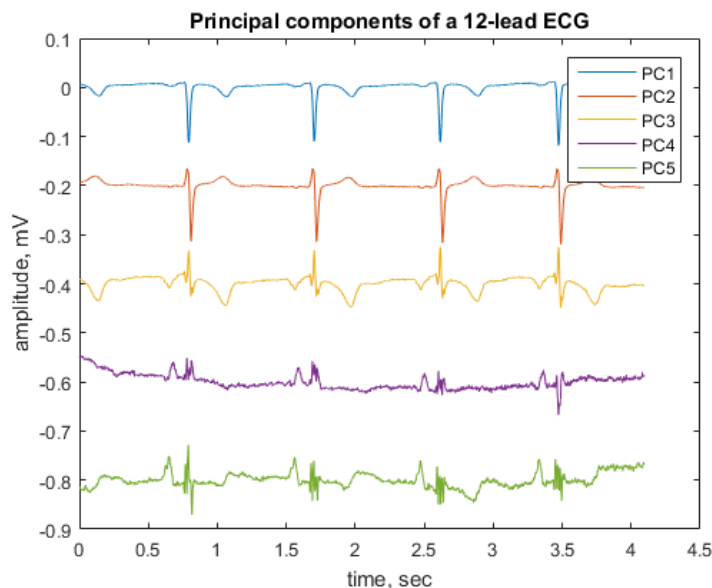
At the end of the semester, your final grade in Canvas will be the final grade. For incompletes and grade appeals, see [University policy](https://catalog.colostate.edu/general-catalog/academic-standards/grading/) (<https://catalog.colostate.edu/general-catalog/academic-standards/grading/>).

HOMEWORK:

Homework will be due at the start of class one week after it is assigned, typically each Thursday, but check the website for updates. Links to the homework can be found on Canvas. I request that you record the time spent on each question on your paper. **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/](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.



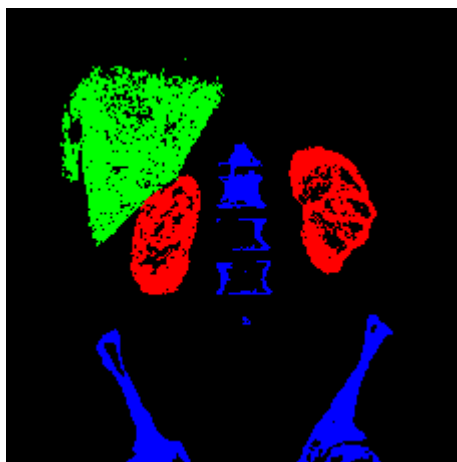
Principal Component Analysis of electrocardiogram recordings.

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.



























Automated segmentation of CT image into liver, kidney, and bone tissue.





Course Summary:

Date	Details	Due
Fri Jan 22, 2021	📄 HW00: MATLAB Onramp https://colostate.instructure.com/courses/118662/assignments/1388014	due by 11:59pm
Tue Jan 26, 2021	📄 Semmlow CH1: Introduction https://colostate.instructure.com/courses/118662/assignments/1387987	due by 12pm
Thu Jan 28, 2021	📄 Semmlow CH2: Measurement, Noise, and Analysis https://colostate.instructure.com/courses/118662/assignments/1387986	due by 12pm
Fri Jan 29, 2021	📄 HW00a: Intro to MATLAB Grader https://colostate.instructure.com/courses/118662/assignments/1420840	due by 11:59pm
Sat Jan 30, 2021	📄 Team preferences survey https://colostate.instructure.com/courses/118662/assignments/1495671	due by 11:59pm
Fri Feb 5, 2021	📄 HW01: Basic ECG Analysis https://colostate.instructure.com/courses/118662/assignments/1388015	due by 11:59pm
Mon Feb 8, 2021	📄 Feasibility proposal https://colostate.instructure.com/courses/118662/assignments/1388004	due by 11:59pm
Tue Feb 9, 2021	📄 Semmlow CH3: Spectral Analysis https://colostate.instructure.com/courses/118662/assignments/1387991	due by 11:59pm

Date	Details	Due
Thu Feb 11, 2021	 Feasibility proposal peer review (https://colostate.instructure.com/courses/118662/assignments/1388005)	due by 11:59pm
Fri Feb 12, 2021	 Semmlow CH4: Digital Filters (https://colostate.instructure.com/courses/118662/assignments/1387993)	due by 11:59pm
Fri Feb 12, 2021	 HW02: Signal and noise (https://colostate.instructure.com/courses/118662/assignments/1388016)	due by 11:59pm
Thu Feb 18, 2021	 Exam 1 Online (https://colostate.instructure.com/courses/118662/assignments/1504057)	due by 11:59pm
Thu Feb 18, 2021	 Exam 1 Online v2 (https://colostate.instructure.com/courses/118662/assignments/1504529)	due by 11:59pm
Fri Feb 19, 2021	 HW03: ECG Frequency Analysis (https://colostate.instructure.com/courses/118662/assignments/1388017)	due by 11:59pm
Tue Feb 23, 2021	 Davis, Cellular Neurophysiology (https://colostate.instructure.com/courses/118662/assignments/1387988)	due by 11:59pm
Thu Feb 25, 2021	 Foster, Electrocardiography (https://colostate.instructure.com/courses/118662/assignments/1387992)	due by 11:59pm
Fri Feb 26, 2021	 HW04: FIR filter design and application to ECG data (https://colostate.instructure.com/courses/118662/assignments/1388018)	due by 11:59pm
Thu Mar 4, 2021	 Foster, Electrocardiography Part II (https://colostate.instructure.com/courses/118662/assignments/1387983)	due by 11:59pm
Fri Mar 5, 2021	 HW04.1: Electrophysiology (https://colostate.instructure.com/courses/118662/assignments/1507860)	due by 11:59pm
Mon Mar 8, 2021	 Feasibility Results and Project Proposal (https://colostate.instructure.com/courses/118662/assignments/1388006)	due by 11:59pm

Date	Details	Due
Wed Mar 10, 2021	 Feasibility results peer review (https://colostate.instructure.com/courses/118662/assignments/1388007)	due by 11:59pm
Thu Mar 11, 2021	 Exam 2 Online (https://colostate.instructure.com/courses/118662/assignments/1387990)	due by 11:59pm
Fri Mar 12, 2021	 HW05: ECG abnormalities (https://colostate.instructure.com/courses/118662/assignments/1388019)	due by 11:59pm
Tue Mar 16, 2021	 Semmlow 16.1--16.4 (classification) (https://colostate.instructure.com/courses/118662/assignments/1387985)	due by 11:59pm
Fri Mar 19, 2021	 HW06: Classification (https://colostate.instructure.com/courses/118662/assignments/1388020)	due by 11:59pm
Tue Mar 23, 2021	 Semmlow CH17: Neural Nets (https://colostate.instructure.com/courses/118662/assignments/1505673)	due by 12pm
Tue Mar 30, 2021	 Semmlow CH12: Image Processing (https://colostate.instructure.com/courses/118662/assignments/1387994)	due by 11:59pm
Thu Apr 1, 2021	 Semmlow CH13: Image Transforms (https://colostate.instructure.com/courses/118662/assignments/1387984)	due by 11:59pm
Fri Apr 2, 2021	 HW07: Image processing basics (https://colostate.instructure.com/courses/118662/assignments/1388021)	due by 11:59pm
Mon Apr 5, 2021	 Project update (https://colostate.instructure.com/courses/118662/assignments/1388026)	due by 11:59pm
Tue Apr 6, 2021	 Jahne Ch 2.3 2D Fourier (https://colostate.instructure.com/courses/118662/assignments/1388025)	due by 11:59pm
Thu Apr 8, 2021	 Semmlow 13.2 image filtering (https://colostate.instructure.com/courses/118662/assignments/1388027)	due by 11:59pm

Date	Details	Due
Fri Apr 9, 2021	 HW08: Image manipulation and filtering (https://colostate.instructure.com/courses/118662/assignments/1388022)	due by 11:59pm
Thu Apr 22, 2021	 Institut Fresnel Fourier plane demonstration (https://colostate.instructure.com/courses/118662/assignments/1388024)	due by 11:59pm
Tue Apr 27, 2021	 Semmlow 15.2 Tomography (https://colostate.instructure.com/courses/118662/assignments/1388028)	due by 11:59pm
Thu Apr 29, 2021	 U. Washington PET Physics Reading (https://colostate.instructure.com/courses/118662/assignments/1388030)	due by 11:59pm
Fri Apr 30, 2021	 HW09: Computed tomography (https://colostate.instructure.com/courses/118662/assignments/1388023)	due by 11:59pm
Tue May 4, 2021	 Semmlow 15.3 Magnetic Resonance Imaging (https://colostate.instructure.com/courses/118662/assignments/1388029)	due by 11:59pm
Tue May 11, 2021	 Final project paper (https://colostate.instructure.com/courses/118662/assignments/1388010)	due by 11:59pm
Wed May 12, 2021	 Final project team self-evaluations (https://colostate.instructure.com/courses/118662/assignments/1388013)	due by 11:59pm
Thu May 13, 2021	 Final project peer review (https://colostate.instructure.com/courses/118662/assignments/1388012)	due by 11:59pm
	 classification exam (https://colostate.instructure.com/courses/118662/assignments/1509225)	
	 Exam 2 -- Electrophysiology, ECG, classification (https://colostate.instructure.com/courses/118662/assignments/1388001)	
	 Exam 2 cheat sheet (extra credit) (https://colostate.instructure.com/courses/118662/assignments/1388000)	

Date	Details	Due
	 Exam 3 (Online) (https://colostate.instructure.com/courses/118662/assignments/1387995)	
	 Exam 3 -- Image processing (https://colostate.instructure.com/courses/118662/assignments/1388003)	
	 Exam 3 cheat sheet (extra credit) (https://colostate.instructure.com/courses/118662/assignments/1388002)	
	 Semmlow CH9: multivariate analysis (https://colostate.instructure.com/courses/118662/assignments/1387989)	