

Biosignals and Systems Analysis

EEL 4930 Section 003

Class Periods: MWF 12:50-1:40

Location: Online

Academic Term: Spring 2021

Instructor

Dr. Nicholas J. Napoli

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Office Hours: Online: Friday at 4pm

Course Description

(3 credits) Fundamentals of applying signal processing methods to physiological systems for interpretable modeling and analysis.

Course Objectives

The class design is structured for undergraduates to be able to understand core fundamental concepts of signal acquisition and characterization of physiological systems for interpretive models and analysis about the human. These signal processing principles and physiology material will be applied to various bio-instrumentation applications such as, electrocardiographs, photoplethysmography, electromyography, electroencephalogram, and other bio-based pressure/force transducers. Students will be able to implement statistical, frequency, and non-linear based time series methods to these physiological systems. Furthermore, they will be able to differentiate which methods and parameters should be utilized for a specific application.

Course Pre-Requisites / Co-Requisites

EEL 4750 - Foundations of Digital Signal Processing

Materials and Supply Fees

Software –MatLab

Professional Component (ABET):

This course consists of 1.5 credits of Engineering Design and 1.5 credits of Engineering Science

Required Textbooks and Software

- Title: Biomedical Signal Analysis: A Case-Study Approach
- Author: Rangaraj M. Rangayyan
- 1st Edition
- ISBN-10: 0471208116

Outcome	Coverage
An ability to understand, identify, and formulate principles and applications of bioinstrumentation for various physiological systems when it comes to signal acquisition and physiological processes.	high

An ability to apply engineering design to produce solutions to physiological systems analysis.	High
An ability to communicate effectively with a range of audiences	low
An ability to recognize ethical and professional responsibilities in engineering situations and make	Medium
An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium
An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions regarding physiological systems	High

Course Schedule

- **Topic 1: Bioinstrumentation** **(Week 1-2)**
 - Biopotentials and Transducers
 - A Quick Review of Fundamentals For Signal Acquisition
 - Amplifiers, Analog-to-digital converters, Nyquist theory, Stationary and Windowing
 - Basic Physiology and Applications
 - Spatial and Temporal Dimensions
- **Topic 2: Filtering and Data Cleaning Applications for Bio-signals** **(Week 3 - 4)**
 - Artifact Rejection and Data Drop Out
 - Resampling, Interpolation, Non-Uniform Sampling, Filtering
 - Moving Average, Moving Median, Hampel Filter
 - Basics of Kalman Filtering
- **Topic 3: Statistical and Time-Frequency Series Physiological Modeling** **(Week 5 - 6)**
 - Basics of Systems Modeling
 - *Revisiting Stationary for Physiological systems*
 - Autoregressive models (AR) and A.R.I.M.A
 - Statistical Correlations for Time Series
 - Template Matching, Match Filtering, etc.
 - Time-Frequency Domain Characterization of Physiological Signals
 - Time Series Data as Projections
 - Basis Functions (e.g. Eigenvalues, a wavelet basis)
 - Statistical Functions (e.g. singular value decomposition, PCA)
 - Short-Time Fourier Transform, Convolution, Wavelets
- **Topic 4: Entropic Methods for Physiological Signals** **(Week 6-8)**
 - Time Series Complexity
 - Entropy Methods
 - Measuring Signal Structural Changes
- **Topic 5: Electromyography (EMG)** **(Week 9-10)**
 - Neuromuscular Physiology and Bioinstrumentation

- Applications of Signal Analysis and Modeling
- **Topic 6: Electrocardiograms (ECG)** **(Week 10-12)**
 - Cardiovascular Physiology and Bioinstrumentation
 - Applications of Signal Analysis and Modeling
- **Topic 7: Cardio-respiratory Systems** **(Week 12-13)**
 - Respiratory Physiology and Bioinstrumentation
 - Applications of Signal Analysis and Modeling
- **Topic 8: Electroencephalogram** **(Week 12-14)**
 - Neurophysiology and Bioinstrumentation
 - Applications of Signal Analysis and Modeling
- **Topic 9: Final Project** **(Week 12-15)**

Evaluation Methods and Criteria

The following section discusses the policies for each of the graded assessments in this course. You should look here first for answers to any general, course-related inquiries.

Homeworks (~10 in total)

When: The Homework assignments will occur roughly once every 1.5 weeks, once each topic is covered. They will be due the following class day when the topic area is finished.

What: Analytical problems that can be solved by hand or application problems that can be solved with Matlab

Why: Homework is intended to guide the student through material and present them with questions that will require time to think and complete. Classwork exercises are meant to be done with your peers and with the instructor's or TAs' help.

Grading: The project is graded on a 100-point scale.

Late policy: Late assignments will not be eligible for any points.

Quizzes (~10 in total)

When: Occur roughly once every 1.5 weeks, once each topic is covered. The quiz will take roughly 15-25 minutes.

What: These quizzes will cover analytical problems, MatLab applications and theory regarding each covered topic from the lectures.

Why: These quizzes are to ensure that student watched/attended the lectures for the current week, to collect feedback from the student, and for them not to fall behind.

Grading: The project is graded on a 100-point scale

Submission: Complete directly on Canvas before 11:59pm every Thursday.

Presentations (~3 in total)

When: Occur roughly once a week, in which the students will sign-up during the semester for their presentation date. Each registration of the three presentations will occur between: Segment 1) weeks 1-7 during the analytics component of the class; Segment 2) weeks 9-14 during the physiology component; Segment 3) weeks 14-15 for the final project

What: These groups presentations are to capture applications and use cases of techniques covered in the field from technical papers and research articles.

Why: These presentation are to improve the students communications skills in the technical domain, engage other students of other novel applications currently being used.

Grading: The project is graded on a 100-point scale and should follow the flow the heilmeier catechism within the presentation.

Submission: Submission would be during the class period for the schedule presentation time

Group Project (1 in total)

When: Groups will be assigned by week seven to begin working to final end of the year project.

What: These group projects are to demonstrate that the student can build upon the concepts within the class and synthesize them to a new application with real physiological data.

Why: The project is to demonstrate the student's ability to synthesize, utilize, and combine everything they have learned through the semester as a team, to create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Grading: The project is graded on a 100-point scale and mimic the quality of an IEEE conference paper. To gauge the level of your contribution, each student will turn in a self-evaluation and an evaluation of their peer's contribution to the project (This will count for 25% of the grade). The final document needs to highlight what were the contributions of the each member of the final submission. The team tasks should not be split into tasks such as coding by student A and writing the paper by student B, this will result as in failure. During the presentation, the students will be given additional questions by the professor to gauge the level of contribution and the alignment of their submitted evaluations. The final project shall be on the topics of biosignal processing learned throughout the course, and consist of the following parts (i) Motivation (ii) Background, (iii) Technical Approach (iv) Results, (v) Discussions, and (vi) conclusions. It will be graded according to the following percentages: 30% for parts (i) and (ii), 45% for parts (iii) and (iv), 25% for parts (v) and (vi). Parts (i), (ii) and (v) shall discuss relations and comparisons between various quantum computing technologies in the course which need to be comprehensive, and parts (ii) and (iv) can focus specifically on one technology.

Submission: Complete and submitted on Canvas by the first scheduled reading day.

Mid-term Exam & Final Exam (1 midterm and 1 final in total)

When: The midterm is half-way thru the course on **Monday, March 8, 2021**, and will cover up to Topic 4. The final is at the end of the course during your set date for the final by the college.

What: Analytical problems that can be solved by hand. Similar to the classwork and big quizzes, but may require a deeper understanding of the material.

Why: Exams are an opportunity to show what the student knows about biosignals and systems analysis.

Grading: Each exam is graded on a 100-point scale.

Make-up Exams: There are no make-up exams, but the final exam may be used in place of the midterm exam.

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance is mandatory. Three unexcused absences without harm to your participation and attendance grade will be provided. If virtual classes are held, attendance is defined by being logon to the virtual provider (e.g., Zoom, Microsoft teams) with your camera on to visually confirm your presence for the entire class time and the ability to respond when called upon. Excused absences must be consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets (10)	100 each	15%

Group Presentations (3)	100 each	15%
Participation & Attendance	100	5%
Quizzes (10)	100 each	10%
Midterm Exam	100	15%
Final Exam	100	20%
Group Project	100	20%
		100%

This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. The exams will also involve additional questions for the graduate section with respect to the undergraduate section. Grading for the homework and projects are different from the undergraduate course. The graduate and undergraduate sections will be graded separately, for which the graduate section has additional problems and different weights for all problems. The presentations and projects for the graduate section will be completed by a single individual verse the undergraduate section will be completed as a group.

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful

manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.