Stochastic Methods for Engineering 2
EEE 6545

Class Periods: Tuesday Period 4 (10:40 AM - 11:30 AM)
Thursday Periods 4-5 (10:40 AM - 12:35 PM)
Location: LEI 0142

Academic Term: Spring 2023

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Course Description
An introduction to stochastic process theory with emphasis on applications to communications, control, signal processing and machine learning. The course covers basic models, including Markov processes, and how they lead to algorithms for classification prediction, inference and model selection.   (3 credits)

Course Pre-Requisites / Co-Requisites
EEL 5544. Experience with Matlab or Python is essential.

Course Objectives
Students will master essential foundations of stochastic processes, and will see how this general theory is applied to design and evaluation of algorithms found in engineering applications. On completing the course, the student will master the following topics:
•   Standard stochastic models found in engineering, including Markov processes, Wiener and Poisson processes, and martingales
•   Relative entropy, mutual information, and their applications to hypothesis testing and communication theory
•   Convergence theory for stochastic processes, with applications to hypothesis testing and other recursive algorithms.
•   Countable-State Markov Models: Classification and convergence properties of Markov processes.
•   Linear filtering, and orthogonal representations (Karhunen-Loeve) for wide sense stationary processes.
•   Inference for Markov Processes: Hidden Markov models, nonlinear filtering and Viterbi's algorithm. Likelihoods and the expectation-maximization (EM) algorithm. Baum-Welch algorithm
•   Optional topics covered in homework, including an introduction to stochastic calculus, introduction to Perron-Frobenious theory and applications; introduction to stochastic approximation; Markov Chain Monte Carlo and applications to learning.

Materials and Supply Fees   N/A

Required Textbooks and Software
- Random Processes for Engineers, Bruce Hajek
Cambridge University Press, 2015
ISBN number - 978-1107100121   Available online:
http://www.ifp.illinois.edu/~hajek/Papers/randomprocJuly14.pdf
- Control Systems and Reinforcement Learning, Sean Meyn
Cambridge University Press, Cambridge, 2022.
ISBN number – 9781009051873   Available online:
https://meyn.ece.ufl.edu/control-systems-and-reinforcement-learning/

Course Schedule
Week 1:   Axioms of probability theory and random variables / Sections 1.1 -1.4   RPE
Week 2:   Expectation, relative entropy and mutual information / Sections 1.5, 1.8-1.11 and handouts
Week 3:   Convergence of random variables / Sections 2.1-2.2 RPE and Sections 8.1-8.3 CSRL
Week 4:   Law of Large Numbers and Central Limit Theorems / Section 2.3-2.4 RPE
Week 5:   Empirical distributions, Large Deviations, and hypothesis testing / Sections 2.4-2.5 and handouts
Week 6:   Conditional expectations and other optimal estimators / Sections 3.1-3.3 RPE
Week 7:   Introduction to stochastic processes / 90 minute Midterm / Sections 4.1 and 4.2 RPE
Week 8:   Linear filtering of processes, and orthogonal representations / Section 3.3 RPE
Week 9:   Nonlinear state space models and Markov chains / Sections 6.1-6.3 CSRL
Week 10:   Markov chains continued, and an introduction to hidden Markov models.
Week 11:   Hidden Markov models, nonlinear filtering and Viterbi's algorithm / Section 5.3 RPE
Week 12:   Statistics: likelihoods and the expectation-maximization (EM) algorithm / Sections 5.1-5.2 RPE
Week 13:   More statistics and the Baum-Welch algorithm / Section 5.3 RPE and handouts
Week 14:   Selected topics in interacting particle systems: MCMC, stochastic approximation & ML / Handout
Week 15:   Review / 90 minute Midterm

Attendance Policy, Class Expectations, and Make-Up Policy
Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Evaluation of Grades
Approximately 8 homework assignments will be assigned to practice theory, and test the theory in computer experiments. Students may work in groups for computational exercises, but must provide their own interpretation of the results, and their own explanations of computer code.

Two in-class exams will test knowledge of the theory and how it can be applied.

One or two in-class quizzes will be held early in the semester to provide essential early feedback.

Assignment	Total Points	Percentage of Final Grade
Homework Sets (8)	100 each	25%
Quizzes (1)	100 each	5%
Midterm Exams (2)	100	70%
		100%

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:
UF Graduate Catalog
Grades and Grading Policies

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/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript

of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

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/process/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 varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

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
• HWCOE Human Resources, 352-392-0904, student-support-hr@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:
<u>Health and Wellness</u>

> **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: https://counseling.ufl.edu, 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 suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/getting-help/; https://distance.ufl.edu/state-authorization-status/#student-complaint.*