

Stochastic Methods for Engineering 2

EEL 6935

Class Periods: T8-9 and Th9

Location: Larsen 239

Academic Term: Spring 2022

Instructor:

Name: Prof. Sean Meyn

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Office Phone Number 392-8934

Office Hours: TBD

Teaching Assistant/Peer Mentor/Supervised Teaching Student: TBD

Course Description

(3 credits) 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.

Course Pre-Requisites

EEE 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-Frobenius 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

- Title- Random Processes for Engineers
- Author- Bruce Hajek
- Publication date and edition- March 16, 2015, Cambridge University Press
- ISBN number- 978-1107100121

Recommended Materials

- Handouts will be made available, and selected sections from the new monograph <https://meyn.ece.ufl.edu/2021/08/01/control-systems-and-reinforcement-learning/>

Course Schedule

Week 1:	Axioms of probability theory and random variables / Sections 1.1 -1.4
Week 2:	Expectation, relative entropy and mutual information / Sections 1.5, 1.8-1.11 and Handout
Week 3:	Convergence of random variables / Sections 2.1-2.2
Week 4:	Law of Large Numbers and Central Limit Theorems / Section 2.3-2.4
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
Week 7:	Introduction to stochastic processes / 90 minute Midterm / Sections 4.1 and 4.2
Week 8:	Survey of special processes: Wiener, Poisson, martingales, Markov property / Sections 4.2-4.8
Week 9:	Linear filtering of processes, and orthogonal representations (Karhunen-Loeve) / Section 3.3
Week 10:	Nonlinear state space models and Markov chains / Handouts
Week 11:	Irreducibility, Lyapunov theory, and ergodic theory for Markov chains. Selected examples: MCMC, applications to stochastic control, reinforcement Learning / Handout
Week 12:	Hidden Markov models, nonlinear filtering and Viterbi's algorithm / Section 5.3
Week 13:	Some statistics: likelihoods and the expectation-maximization (EM) algorithm / Sections 5.1-5.2
Week 14:	More statistics and the Baum-Welch algorithm / Section 5.3 and handouts
Week 15:	Review / 90 minute Midterm

Attendance Policy, Class Expectations, and Make-Up Policy

Excused absences must be in compliance with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations/>) and require appropriate documentation.

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 exam to provide essential early feedback.

Assignment	Percentage of Final Grade
Homework Assignments	25%
Quizzes	5%
Midterm Exams	70%

Grading Policy

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 - 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 77.9	C+	2.33
72.0 - 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at: <https://catalog.ufl.edu/graduate/regulations/>

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure 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>.