ISYE 4601:
Online Learning and Decision-Making

Fall 2025. Tu/Th 9:30-10:45am, IC 105

Summary of course

At the heart of most machine learning applications today – like advertisement placement, movie recommendation, and node prediction in evolving networks – is an optimization engine trying to provide the best decision with the information observed thus far in time, i.e. the problem of *online learning*. To solve these problems, one must make online (meaning dynamic/real-time in machine learning linguo) decisions and continuously improve the performance with the arrival of data and feedback from previous decisions.

The course aims to provide a foundation for the development of such online methods and for their analysis. We will discuss fundamental principles for learning from an unknown environment, limited feedback, and learning with dynamic, long-term consequences. If time permits, we will also discuss the ethics of online machine learning and decision-making.

What you will learn:

Upon successful completion of the course, you will have been exposed to

- The applications of online learning
- The main algorithms that make real-time, online possible, and how to apply them.
- How both exploration of the decision space and exploitation of historical data must be prioritized to be able to reach optimal decisions.
- Advanced and special topics in online learning

Pre-requisites

ISYE 3133 (Optimization) + ISYE 2027 (Probability). This is an advanced course, and there is a lot of subtle mathematics that we will cover to understand the basics of online machine learning. We will expect some mathematical maturity in linear algebra and analysis as well. Assignment 0 covers the background needed for this class. Note that the assignments in this course are mathematical as well as programming-based and require a working knowledge of Python.

Staff

Instructor – Prof. Juba Ziani, Georgia Tech IsyE. jziani3@gatech.edu

TAs

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Schedule and Location

Lecture: TBD

Instructor office hours:
- TBD

TA Office Hours:
- TBD

Grading

The course will be graded on the following components:

- **Assignment 0 (3%)**: Assignment 0, which will be released on Jan 7th (first lecture), will be shorter than the other assignments and will cover prerequisite material for the class. If you struggle on assignment 0, please talk to me to see how to move forward.
- **Homeworks (45%):** There will be 3 homework assignments in total. Further details on homework are listed below. The timeline might be modified a bit to accommodate midterm periods, breaks, etc.
- **Two midterms (30% in total):** There will be two midterm exams (each of which contribute to 15% of your grade) that will test conceptual and technical knowledge of the foundational components of online learning and decision-making. Tentative timeline below.
- **Final exam (20%):** The final exam will cover the entire course. More information to come later during the semester
- **Participation (2%):** will cover in-class participation, Piazza, and office hours. Not all are required for full points, you just need to engage with the class in some of these ways!

The students' final grade will be assigned as a letter grade according to the scale:
A: 90-100%
B: 80-89%
C: 70-79%
D: 60-69%
F: <= 59%

I do not anticipate curving the grades (typically class GPA is high without curving).

Homework

Some general guidelines for homeworks:

- **Submission guidelines:** The assignments will be released on and have to be submitted online via Canvas – either with typed up solutions (in this case, LaTeX is preferred for typesetting math) or pictures of your own handwritten notes.
- **Coding-based questions:** For coding based questions, please submit not just the output of your code, but also the code itself (in particular, if the output does not quite match, this will help give you partial credit!)
  Note that students will need a working knowledge of Python (basic packages) and Jupyter notebooks to solve the coding-based questions (there will be such questions in the assignments but not in the exam).
- **Collaboration policy:**
  - You are encouraged to discuss homework/assignments problems with your fellow students for homeworks 1-3. However, *each student must write up and turn in their own solutions written in their own words.*
  - Homework 0 is an exception and must be completed *on your own*. Think of it as a way to test yourself on pre-requisites/how ready you are to take the class!
- **Late submissions:** You have 3 tokens, one giving you 1 day late each, throughout the semester; tokens will be used automatically if you submit your problem set late. In case of illness or emergency that would prevent you from completing the problem sets on time, please let me know so that we can make arrangements.

  Beyond tokens and exemptions: if you have used up all of your tokens, and need to submit a problem set late, the rule is that you will lose 5% to your *maximum* grade per hour late. Imagine your grade was 93/100 and you submitted one hour late; the rule is that you could not get more than 95 points, but you would *still* get 93 as your final grade. But two hours late and you would get 90, three hours 85, etc.

Book and resources:

The book originally developed by Dr. Swati Gupta and Jad Salem will be posted on Canvas and is a great source of supplementary material which closely match the topics we will study in class----I recommend looking at it! While the lecture notes should be fairly complete, this is a very good resource to deepen your understanding of online learning/decision-making. The instructor's lecture notes and recorded lectures will also be posted after each lecture.

The references below are optional and the material on canvas should be self-contained:

- Nicolo Cesa-Bianchi and Lugosi: Prediction, Learning and Games
- Elad Hazan: Introduction to online convex optimization
- Tor Lattimore and Csaba Szepesvari: Bandit algorithms

Expectations and guidelines

Academic Integrity - yada yada you know the drill please don't make me report you I'd be sad: Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit https://catalog.gatech.edu/policies/honor-code/ or https://catalog.gatech.edu/rules/18/

Accommodations for students with disabilities: If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404) 894-2563 or disabilityservices.gatech.edu, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also email the instructor as soon as possible in order to set up a time to discuss your learning needs.

Representative timeline and schedule (old dates, to be updated)

Date	**Topic**	**Additional resources guide** (internally available on Canvas)
Aug 19	Logistics and introduction. **HW0 released**.	N/A
Aug 21	Review session on prerequisites	Chapter 1 of the book
Aug 26	Start of Part I: Basics of prediction for binary decisions	Chapter 2 of the book.
Aug 28	Binary sequence prediction using perfect expert advice: Halving algorithm. **HW0 due 29th. HW1 released weekend.**	Chapter 3 of the book.
Sep 2	Binary sequence prediction using perfect expert advice: Halving algorithm.	Chapter 3 of the book.
Sep 4	Out-of-town	
Sep 9	Prediction with expert advice beyond binary decisions: Multiplicative Weights algorithm	Chapter 4 of the book.
Sep 11	Application: solving linear programs.	Chapter 5 of the book.
Sep 16	Review: Full-information online learning.	
Sep 18	Out-of-town (conference)	
Sep 23	Start of Part 2: Introduction to limited-information feedback; exploration-vs-exploitation.	
Sep 25	Limited-information feedback, randomized-greedy and Exponential Weights. **HW1 due. HW2 released.**	

Sep 30	**In-class midterm 1 (covers Part I only)**	
Oct 2	~~Cancelled lecture.~~	
Oct 7	Fall break	
Oct 9	Limited-information feedback: UCB.	
Oct 14	Limited-information feedback: end of UCB. Bayes updates, intro to Thompson sampling	
Oct 16	Limited-information feedback, Thompson sampling part 2.	
Oct 21	Start of Part IIIa: introduction to long term decision-making and reinforcement learning.	
Oct 23	Review for midterm 2. **HW2 due.**	
Oct 28	No class for INFORMS. **Recorded lecture:** application to recommender systems.	
Oct 30	**In-class midterm 2.**	
Nov 4	Backwards induction and dynamic programming. **HW3 released.**	
Nov 6	Out-of-town (conference)	
Nov 11	Re-dynamic programming and Markov decision processes.	
Nov 13	Ou-of-town (conference)	
Nov 18	Start of Part IIIb: Introduction to fairness + measures and metrics of fairness (part I)	
Nov 20	Measures and metrics of fairness (part II)	
Nov 25	COMPAS example and case study. **HW3 due**.	
Nov 27	Thanksgiving	
Dec 2	Review for final.	
Exam matrix	**Final exam (8:00am-10:50am)**	