DS 340: Introduction to Machine Learning and AI

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Course Dates: 9/2/25-12/19/25
Course Time & Loc:
A1: TuTh 2PM-3:15PM
8 St. Mary's St PHO 210
B1: TuTh 9:30AM-10:45AM
CAS 203
Course Credits: 4

Course Description

From chatbots to speech recognition to image analysis and manipulation, machine learning (ML) and artificial intelligence (AI) are becoming ubiquitous in enabling applications that adapt to users and work with natural data, and it is becoming increasingly important to understand how these algorithms work, learn how to harness their power in applications, and become familiar with the advantages and disadvantages of different approaches. This course instructs students in key algorithms for artificial intelligence (AI) and machine learning (ML). This includes depth in the most popular machine learning approach, neural networks, as well as breadth in other AI approaches (such as search for game-playing) and other ML approaches (such as random forests). A final project will assess the depth of self-guided learning in an area of AI/ML of the student's choosing, while homework and exams will ensure passing familiarity with other major techniques.

The primary assessment tools will be a midterm, a final exam, and a final project of the student's own design. There will also be points awarded for participation and completing homework.

Prerequisites

Algorithms (DS320 or equivalent) should be taken simultaneously with or prior to this class. Note that in the DS sequence, this presumes a second semester of programming (DS210) and a completed math sequence that includes probability, linear algebra, and some multivariable calculus (DS120-121-122). If you are coming to this class through a different path, be aware that you will need to learn some of this math, as well as some object-oriented Python.

Learning outcomes

Students will be able to program and reason about a variety of algorithms in AI and Machine Learning, including Naive Bayes, Decision Trees, Random Forests, Neural Networks, and Q-Learning, in addition to a deep dive into the AI/ML technology of their choosing. Students should also be able to thoughtfully discuss AI in the context of ethics or predicting trends.

Instructional Format, Course Pedagogy, and Approach to Learning
The main instructional format will be lectures with occasional questions to the audience. In discussion section, students will discuss philosophical or high-level questions, and also practice the application of AI and ML ideas to code.

A large part of the learning will be in the programming assignments, the discussion questions to answer, and the final project. But a midterm and final exam will also ensure that students are learning about everything the course has to offer, and not just what is tested in these components.

Books and Other Course Materials

Recommended textbook and readings: Russell and Norvig's *Artificial Intelligence: A Modern Approach* (4th edition, ISBN-13 78-0134610993). I will provide optional readings in the syllabus tied to this book. It is useful for accessible explanations that add depth beyond what we have time to cover in lecture. Some important papers will also be made available on Blackboard.

Recommended hardware: All homework will be run on Google Colab in the cloud, so you actually don't need a powerful machine for this course, as long as it has a Chrome web browser. If you lack a laptop, you can **borrow an acceptable one from BU**. Some compute-intensive projects could require a robust modern machine with a good graphics card to run at an acceptable speed - but if you don't have such a machine, you can just choose from many other project topics.

Courseware

The main course materials will be available on Blackboard, and Q&A will take place on Piazza.

Google Colab (for programming work): https://colab.research.google.com/
Blackboard (assignments and lecture notes): https://learn.bu.edu/
Piazza link and staff office hours: https://piazza.com/bu/fall2025/ds340/staff
Access to the high-performance Shared Computing Cluster (SCC): scc-ondemand.bu.edu

Assignments and Grading

The main components of the course grade are:

Assignments	10%
Section participation	5%
Lecture participation	10%
Midterm	15%
Project	30%
Final exam	30%

AI use on assignments is permitted as long as you disclose it. The lecture participation grade requires contributing to discussions or otherwise contributing to class at least once every three weeks. The section participation grade requires good faith effort on the weekly exercises in section. The project grade includes the proposal, a final presentation, a final paper, and the working code itself.

The lowest assignment grade that is *not* the ethics assignment will be dropped. If errors on the student's end cause a (non-ethics) assignment to fail to be submitted properly, that is the grade that will be dropped.

All the assignments are weighted equally, even if maximum point values differ.

Resources/Support/How to Succeed in This Course:

1. I recommend coming to office hours (mine or the TAs') if you are stuck on homework, and we will help you get unstuck. (If you are confused about material, the textbook is also very good.) Office hours time is dedicated explicitly to helping you, so don't be afraid to come.
2. If family, health, or other unavoidable circumstances make it impossible to do your work on time, get in touch, and we can probably work something out. I will want a note from a relative, medical professional, or similarly informed person for confirmation.
3. Accommodations for Students with Documented Disabilities: If you are a student with a disability or believe you might have a disability that requires accommodations, please contact the Office for Disability Services (ODS) at (617) 353-3658 or access@bu.edu to coordinate any reasonable accommodation requests. ODS is located at 25 Buick Street on the 3rd floor. Contact the testing center well in advance of exams that you need accommodation for; we can't guarantee accommodation if they run out of space.

Community of Learning: Class and University Policies

1. Please do ask questions in class when you're unclear about something. But if you've asked a lot of questions already, try to make room for others in the class to ask something. The participation card system is trying to spread out participation across the class; please try to respect that intention and avoid dominating the discussion.

2. **Attendance & Absences.** Attendance is strongly encouraged to help you do well on the exams. It's also necessary to get the participation credit for speaking in class and doing the section exercises. I affirm the Policy on Religious Observance. We can waive attendance for other reasonable reasons, but if you need to move an exam, I need a note from a relative or professional that confirms the move is truly unavoidable.

3. **Assignment Completion & Late Work**. Assignments will be turned in via Blackboard. Students can use up to 5 late days on assignments, no more than 2 per assignment, to turn in work late. Assignments will not be accepted after the late days are used up or after two

days. **Participation credit work and project components can't be turned in late.** If you have extenuating circumstances such as health reasons that make it impossible to complete the assignment on time, contact me to apply for an extension or a waived assignment; it will require a note from a parent or other person familiar with your situation.

4. **Academic Conduct Statement.** Collaborations with other students and use of code from the web or ChatGPT-like AIs should always be acknowledged in the assignment or project. **Plagiarism, the reuse of code or text without acknowledgment of the source, is forbidden and punishable with a zero on the assignment and a plagiarism case.** Code from AIs should be acknowledged with comments in the code. Students can't share or copy each others' code, but they can otherwise collaborate on homework assignments (discussing approaches and solutions) as long as they cite the students they collaborated with in their submission. Some guidelines for what is considered plagiarism in the case of code are here: https://www.bu.edu/cs/undergraduate/undergraduate-life/academic-integrity/. The general academic conduct code is here: https://www.bu.edu/academics/policies/academic-conduct-code/

Hub Learning Outcomes

1. **Quantitative reasoning II** - Students will develop several technical skills, including using search algorithms and employing machine learning. They will even develop skill in probabilistic reasoning itself. These skills will be developed through programming problem sets and the final project. Assignments include practice with tabular machine learning, image recognition, and reinforcement learning.

1. *Students will frame and solve complex problems using quantitative tools, such as analytical, statistical, or computational methods.*

The variety of computational tools that students will use to solve include ensemble methods, neural networks, and Q-learning.

2. *Students will apply quantitative tools in diverse settings to answer discipline-specific questions or to engage societal questions and debates.*
   In their final projects, students will have the freedom to apply the techniques they've learned to a variety of domains, including the political if they choose to analyze Tweets and similar data. Students will see a variety of domains through each others' presentations.
3. *Students will formulate, and test an argument by marshaling and analyzing quantitative evidence.*
   Students will argue positions about AI during dedicated topic discussions.
4. *Students will communicate quantitative information symbolically, visually, numerically, or verbally.*
   Students will need to communicate about their final projects in their presentations and final papers.

5. *Students will recognize and articulate the capacity and limitations of quantitative methods and the risks of using them improperly.*
   Students will answer response questions in which they evaluate whether AI techniques are being misapplied.

2. **Ethical reasoning** - We will devote one full day to ethical instruction late in the semester, but will also pose ethical discussion questions throughout the semester. Key questions include whether a robot or algorithm designer is responsible for uses of their technology they didn't foresee, and arguing whether it's better to place ethical value on ethical rules or anticipated consequences. Students will be evaluated on their short discussion question responses.

   1. *Students will be able to identify, grapple with, and make a judgment about the ethical questions at stake in at least one major contemporary public debate, and engage in a civil discussion about it with those who hold views different from their own.*
      Students will have a public discussion about whether it's wrong to perform research that advances drone weapon technology, whether it's wrong to automate away jobs, and similar discussions.

   2. *Students will demonstrate the skills and vocabulary needed to reflect on the ethical responsibilities that face individuals (or organizations, or societies or governments) as they grapple with issues affecting both the communities to which they belong and those identified as "other." They should consider their responsibilities to future generations of humankind, and to stewardship of the Earth.*
      Students will learn to identify different ethical stances as act consequentialist or rule consequentialist, and will learn about how these two different stances think differently about the far future.

3. **Critical thinking** - Artificial intelligence and machine learning are constantly producing grand claims where the reality is more humble. Discussion questions will ask students to evaluate some of the grander futurist claims while considering the current state of the art. While students won't be required to give up on big claims, the discussion should temper those expectations. To a lesser extent, their experience with the technologies in problem sets and projects may also help them to see the current limitations more clearly. This course also teaches probabilistic reasoning, which is applicable to human reasoning as well.

   1. *Students will be able to identify key elements of critical thinking, such as habits of distinguishing deductive from inductive modes of inference, recognizing common logical fallacies and cognitive biases, translating ordinary language into formal argument, distinguishing empirical claims about matters of fact from normative or evaluative judgments, and recognizing the ways in which emotional responses can affect reasoning processes.*
      Students will learn that the inferences of machine learning are not the same as logical deduction, and will identify ways in which machine learning can be illogical. This will include answering response questions in the homework in which they must explain how machine learning could come to biased or incorrect results, or how it could differ in approach and results from a purely logical approach.

2. *Drawing on skills developed in class, students will be able to evaluate the validity of arguments, including their own.*
   Students will evaluate claims made about AI technologies in response questions. If a student is selected for class participation, they may need to defend or elaborate on their position.

Outline of Class Meetings: Date, Topic, Readings, Assignments Due

Schedule of Readings and Due Dates	(R&N is Russell & Norvig 4th edition)
Sep 2	Introduction & history of AI R&N 1.1, 1.3, 2.1, 2.2
Sep 4	Two classifiers R&N 12.6, 19.6.4-19.6.5
Sep 9	Local search [HW1 out] R&N 4.1-4.2, Ch4 hist notes, 19.6
Sep 11	Intro to ML, Decision trees R&N 19.1-19.3
Sep 16	Ensemble ML [HW1 due, HW 2 out] R&N 19.7-19.8
Sep 18	Regularization R&N 19.4, 19.5
Sep 23	Kernel methods [HW2 due] R&N 19.7.5-19.7.6
Sep 25	Neural networks (NNs) R&N 21.1-21.2
Sep 30	Deep NNs 1 R&N 21.3-21.8
Oct 2	Deep NNs 2 [HW3 out]
Oct 7	NNs over time [FP Proposal out] R&N 21.6
Oct 9	Midterm review [HW3 due]
Oct 14	NO CLASS - Monday Schedule
Oct 16	MIDTERM
Oct 21	NNs and language [FP proposal due, HW4 out] R&N Ch 24
Oct 23	LLMs
Oct 28	LLMs 2 [HW4 due, HW5 out]
Oct 30	Utility & MDPs, Intro to RL R&N 16.1-16.3, 17.1-17.4, 17.6, 22.1-22.3
Nov 4	RL cont'd R&N 22.4, Mnih et al 2013

Nov 6	RL cont'd [HW5 due, HW6 out]
Nov 11	Minimax & MCTS R&N 5.1-5.5
Nov 13	Ethics of AI [HW6 in, Ethics out] R&N 20.3
Nov 18	Recommender Systems https://tinyurl.com/4m9cymmn
Nov 20	Autoencoders & GANs [Ethics in]
Nov 25	Diffusion models and AI Art
Nov 27	NO CLASS - THANKSGIVING
Dec 2	Philosophy of AI, Conclusions R&N 27.1-3
Dec 4	Final project lightning talks 1
Dec 8	*Final Project due*
Dec 9	Final project lightning talks 2
Dec 15-19	Final Exam period

~last modified 8/22/25~