NYU TANDON SCHOOL OF ENGINEERING

Course Syllabus

Computer Science and Engineering

CS-GY 6923-Machine Learning

Course Information

Course Prerequisites

- Basic understanding of probability, linear algebra, and computational algorithms
- Basic facility in programming in Python

Course Description

This online course is aimed at developing practical machine learning and data science skills. The course will cover theoretical basics of broad range of machine learning concepts and methods with practical applications to sample datasets via programming assignments.

Upon completion of this course you will have acquired the following knowledge:

- Describe the principal models used in machine learning and the types of problems to which they are typically applied.
- Compare the assumption made in each model and the strengths and weakness of each model.
- Determine to which problems machine learning is applicable and which model or models would be most appropriate in each case.
- Apply the principal models in machine learning to appropriate problems

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Course Structure

This course is conducted entirely online, which means you do not have to be on campus to complete any portion of it. You will participate in the course using NYU Classes located at https://newclasses.nyu.edu. Lectures will become available at midnight each week and will be delivered through Active Learning Modules* in NYU Classes. In addition to lectures, participation will play a key role in this course. Students are expected to participate in weekly discussion forums and webinar sessions.

Grading Breakdown

- 40% Weekly Assignments
- 20% Engagements
- 40% Final Project

Learning Time Rubric

Learning Time Element	**Asynchronous* / Synchronous* ***	**Time on Task for Students (weekly)**	**Notes**
Lecture	Asynchronous	2 hours	Video format. Expect quizzes throughout the module.
Weekly Discussion Board	Asynchronous	1 hour	Students are expected to post initial response to weekly topic questions. See Interaction Policy.

Programming Assignment	Asynchronous	2 hours	Students submit their assignment
Project	Asynchronous	1 hour	
Reading Assignment	Asynchronous	2 hours	Reading assigned textbook chapter

*Asynchronous learning is defined as any non-real time student learning, such as recorded lecture, podcast, interactive module, articles, websites, etc. This also includes any student-to-student or faculty-to-student communication that may happen with an asynchronous tool, such as discussion board, chatroom, e-mail, text, etc.

**Synchronous learning is defined as any real-time student-to-student and/or faculty-to-student learning, such as a live webinar session or other video/audio communication service.

Course Communication

Announcements

Announcements will be posted on NYU Classes on a regular basis. You can locate all class announcements under the Announcements tab of our class. Be sure to check the class announcements regularly as they will contain important information about class assignments and other class matters.

Email

You are encouraged to post your questions about the course in the Forums discussions on NYU Classes. This is an open forum in which you and your classmates are encouraged to answer each other's questions. But, if you

need to contact me directly, please email me. You can expect a response within 48 hours.

Weekly Discussion Forums

Discussion forums are an excellent way for you to engage with the course material and with your peers. Each module will have an accompanying discussion board question posted in the Forums tab. You are expected to read the discussion boards and engage in thoughtful discussions. I will read all discussion posts and provide content clarification and feedback when necessary.

Weekly Virtual Meetings

Once a week, we will hold a virtual class meeting through the Meetings tool on NYU Classes. This weekly meeting is an opportunity for you to ask questions and gain clarification about the course content from myself and your peers. You are highly encouraged to attend these meetings. I understand that not all students will be available to attend these virtual meetings. Due to this fact, the meetings will be recorded so you can watch them when you are available.

Etiquette

When participating in an online class it is important to interact with your peers in an appropriate manner. Always use professional language (no netspeak) in your discussion board posts and emails. Please be respectful of your classmates at all times even if you disagree with their ideas.

Interaction Policy

You are required to be an active online learner in this course and expected to participate in the Active Learning Modules, weekly discussion boards, weekly virtual meetings

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Readings

The required texts for the course are

1. *Introduction to Machine Learning, Third Edition*, Ethem Alpaydin, MIT Press, 2014
2. *Python Machine Learning: Machine Learning and Deep Learning with Python, scikit learn, and TensorFlow 2, Third Edition*, Sebastian Raschka and Vahid Mirjalili, Packt Publishing, 2020.

You can access NYU's central library here: http://library.nyu.edu/

You can access NYU Tandon's Bern Dibner Library here: http://library.poly.edu/

Course Requirements

Participation is paramount to your success in this course. Be sure to log into NYU Classes multiple times a week, read all announcements, complete all Active Learning Modules and assignments on time, and participate in Discussion Forums and Virtual Meetings.

Topics

Topic 1:

Introduction to the course and to machine learning

- Objective: Be able to describe, at a very high level, what machine learning is and why it is becoming increasingly prevalent.

Readings:

- Alpaydin, Chapters 1 and 2. Read for the big picture. Don't get stuck on the details.

Webinar Session

Discussion Forum

- Introductory post about yourself.

Programming Assignment:

- Set up your Jupyter notebook environment.

Topic 2:

The Perceptron and Adaline machine learning models

- Objectives: Be able to describe and implement the Perceptron and Adaline machine learning models. Be able to compare the assumptions of these two models and discuss their strengths and weaknesses.

Readings:

- Alpaydin, Ch. 11.1 - Ch. 11.4
- Raschka, Ch 2., pp 1-50; Ch 3., pp 51-58.

Webinar Session

Discussion Forum

Programming Assignment 2

Topic 3:

Logistic regression model, regularization. Multiclass classification

- Objectives: Be able to describe and implement the logistic regression machine learning model. Be able to describe regularization, determine

to which machine learning situations it is applicable, and apply it. Be able to apply binary classification models to multiclass problems.

Readings:

- Alpaydin, Ch. 10
- Raschka, Ch 3. pp 51-58.

Webinar Session

Discussion Forum

Programming Assignment 3

Topic 4:

Support Vector Machines and Kernel Machines

- Objectives: Be able to describe the support vector machines and kernel machines. Implement SVM and kernel machine learning models.

Readings:

- Alpaydin, Ch. 10
- Raschka, Ch 3. pp 76-87

Webinar Session

Discussion Forum

Programming Assignment 4

Topic 5:

Decision Trees and Decision Tree Pruning

- Objectives: Be able to describe and implement the decision tree machine learning model and to determine when pruning is appropriate and, when it is appropriate, implement it.

Readings:

- Alpaydin, Ch. 6 and Ch. 9.
- Raschka, Ch 3, pp. 88-97.

Webinar Session

Discussion Forum

Programming Assignment 5

Topic 6:

Bayesian Learning

- Objective: Be able to describe and implement Bayesian machine learning models.

Readings:

- Alpaydin, Ch. 3

Webinar Session

Discussion Forum

Project Description

Topic 7:

Ensemble Methods

- Objectives: Be able to describe the difference between strong and weak learnings. Be able to describe the techniques of bootstrapping, gradient boosting, and Adaboosting. Be able to describe and implement the random forest machine learning model.

Readings:

- Alpaydin, Ch. 17
- Raschka, Ch. 7

Webinar Session

Discussion Forum

Programming Assignment 7

Topic 8:

Regression

- Objectives: Be able to describe how to use multiple machine learning models to solve regression problems and to implement these techniques.

Readings:

- Alpaydin, Ch. 7, 8
- Raschka, Ch. 10, 11

Webinar Session

Discussion Forum

Programming Assignment 8

Topic 9:

Clustering and Nonparametric Models Including PCA. Dimensionality Reduction

- Objectives: Be able to describe and implement clustering and nonparametric models

Readings:

- Alpaydin, Ch. 7, 8
- Raschka, Ch. 10, 11

Webinar Session

Discussion Forum

Submit Project Topic

Topic 10:

Neural Networks and Backpropagation

- Objective: Be able to describe the technique of backpropagation. Be able to describe and implement machine learning models based on neural networks

Readings:

- Alpaydin, Ch. 11.5-11, 13

- Raschka, Ch. 12

Webinar Session

Discussion Forum

Topic 11:

Other topics in Neural Networks

- Objective: Be able to describe and implement techniques utilizing convolutional neural networks, recurrent and recursive neural networks, and hidden Markov models.

Readings:

- Alpaydin, Ch. 15

Webinar Session

Discussion Forum

Topic 12:

Reinforcement Learning

- Objective: Be able to describe and implement reinforcement learning machine learning techniques

Readings:

- Alpaydin, Ch. 18

Webinar Session

Discussion Forum

Submit Project Report Draft

Topic 13:

Generative Adversarial Networks, Ethics and Fairness in Machine Learning, and Concluding Comments

- Objectives: Be able to describe Generative Adversarial Networks. Be able to describe ethical and fairness issues in machine learning.

Readings:

- Arvind Narayanan, Twenty one definitions of fairness and their policies, ACM FAT* 2018, https://www.youtube.com/watch?v=jIXIuYdnyyk
- Moritz Hardt, Eric Price, and Nathan Srebro, Equality of opportunity in supervised learning, 2016.

Webinar Session

Discussion Forum

Topic 14:

Presentation of Final Projects

University Policies

Moses Center Statement of Disability

Academic accommodations are available for students with disabilities. Please contact the Moses Center for Students with Disabilities (212-998-4980 or mosescsd@nyu.edu) for further information. Students who are requesting academic accommodations are advised to reach out to the Moses Center as early as possible in the semester for assistance.

NYU Tandon School of Engineering Policies and Procedures on Academic Misconduct[1]

A. Introduction: The School of Engineering encourages academic excellence in an environment that promotes honesty, integrity, and fairness, and students at the School of Engineering are expected to exhibit those qualities in their academic work. It is through the process of submitting their own work and receiving honest feedback on that work that students may progress academically. Any act of academic dishonesty is seen as an attack upon the School and will not be tolerated. Furthermore, those who breach the School's rules on academic integrity will be sanctioned under this Policy. Students are responsible for familiarizing themselves with the School's Policy on Academic Misconduct.
B. Definition: Academic dishonesty may include misrepresentation, deception, dishonesty, or any act of falsification committed by a student to influence a grade or other academic evaluation. Academic dishonesty also includes intentionally damaging the academic work of others or assisting other students in acts of dishonesty. Common examples of academically dishonest behavior include, but are not limited to, the following:
    a. Cheating: intentionally using or attempting to use unauthorized notes, books, electronic media, or electronic communications in an exam; talking with fellow students or looking at another person's work during an exam; submitting work prepared in advance for an in-class examination; having someone take an

[1] Excerpted from the Tandon School of Engineering Student Code of Conduct

exam for you or taking an exam for someone else; violating other rules governing the administration of examinations.

b. Fabrication: including but not limited to, falsifying experimental data and/or citations.
c. Plagiarism: intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise; failure to attribute direct quotations, paraphrases, or borrowed facts or information.
d. Unauthorized collaboration: working together on work that was meant to be done individually.
e. Duplicating work: presenting for grading the same work for more than one project or in more than one class, unless express and prior permission has been received from the course instructor(s) or research adviser involved.
f. Forgery: altering any academic document, including, but not limited to, academic records, admissions materials, or medical excuses.