CS 6501 - Learning Theory: Syllabus

Department of Computer Science
University of Virginia

SPRING 2019

Time and Location

Mondays, Wednesdays, and Fridays, 1:00pm–1:50pm, Olsson Hall 009.

Website: http://www.cs.virginia.edu/diochnos/teaching/

We will also be using Collab to send mass announcements and potentially assign homework and projects.

Instructor

Dimitris Diochnos, 532 Rice Hall, diochnos@virginia.edu.

Teaching Assistant

The graduate student Suya (fs5xz) will be a teaching assistant for this course this year.

Office Hours

Tuesday. Dimitris, 11am–1pm at 414 Rice Hall.

Wednesday. Dimitris, 2pm–4pm at 414 Rice Hall.

Friday. Suya, 2pm–6pm at 436 Rice Hall.

• If you want to meet us outside of our office hours, the most reliable method is to send an email and arrange an appointment.

Prerequisite Background

Design and analysis of algorithms, basic computational complexity theory, and graduate level mathematical maturity. Tools from probability theory will be discussed (briefly) on demand as they arise.
Topics and Course Description

Learning theory is a field that develops models for capturing learning phenomena and ultimately studies the efficiency and the limitations of learning algorithms in these frameworks. We will explore basic aspects of machine learning theory. We will start with learning algorithms that use membership and equivalence queries, version spaces, and decision trees. We will then switch to the probably approximately correct (PAC) model of learning, Occam’s razor, VC theory, and ultimately prove the fundamental theorem of learning theory. From this point and on, we will cover, not necessarily in this order, the following topics. The relationship between weak and strong learning (boosting). Online learning and learning with expert advice in the mistake bound model, where we will see algorithms such as randomized halving, weighted majority, and winnow. We will also cover aspects of adversarial machine learning (poisoning and evasion attacks) and thus explore connections between machine learning and security. Time permitting, there are further ideas for related interesting topics. For example, theoretical aspects of learning that are related to evolution and evolution seen as a learning process drawing results from evolutionary algorithms and Valiant’s framework of evolvability, or active learning.

Schedule of Classes

The following schedule is indicative and is continuously subject to change. We will cover the material at a pace that is comfortable. Our first meeting is on Monday, January 14, 2019 and our last meeting is on Monday, April 29, 2019. The final is on Friday, May 3, 2019 between 9:00am and 12:00pm.

**Weeks 1-2:** Introduction, concept learning, membership and equivalence queries, version spaces, and search algorithms.

**Weeks 3-4** Decision tree learning and perceptron.

**Weeks 5-9:** PAC learning, Occam’s razor, VC theory and sample complexity bounds. Weak and strong learning, boosting. During this period we will have the midterm. Either during the week before the spring break, or right after the break.

**Week 10:** Online models.

**Weeks 11-15:** Adversarial machine learning and potentially other topics depending on our pace.

**April 29:** Last class; ask me anything.

**May 3:** Final exam.

**No Classes.** No classes on the following days:

- Martin Luther King Day: Monday, January 21, 2019.

Textbook and Notes

A big part of the course will rely on [2]. Topics not found in [2] will be based on papers or other notes that are available online or presented in class and thus all the students will have access to. Relevant references will be given through the course website(s) or mass announcements. Further, a classical resource for covering aspects relevant to the PAC model of learning is [1]. It is advised that the students take notes from the material that is covered in class.

Another very good reference for our course can be [3]. Note that the book is available online at the following address: [http://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/](http://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/).

Finally, Valiant’s book [4] provides a good narrative for connections that we may discuss between evolution and learning.
Grading

Graduate students will have to do a small project for the course. That project is optional for undergraduates.

With Final Project. Grading will be based on the following:

- 40% homework problems,
- 20% final project,
- 20% in-class midterm exam,
- 20% in-class final exam.

Without a Final Project. Grading will be based on the following:

- 50% homework problems,
- 25% in-class midterm exam,
- 25% in-class final exam.

Grades may also be adjusted slightly upward or downward depending on class participation.

Final Project

Graduate students should deliver a final project. This is optional for undergraduates.

In general I am open to discussion for various ideas regarding the final project. The route that I expect most people will take, is to form a group of 3-5 people, read a research paper and write a summary that will be about two pages long (11pt) and be distributed to the rest of their students in class. Depending on our pace as well as on the number of different groups of students that are formed for a final project we may or may not have oral presentations of these research papers. Another idea is for a group of people to implement a library with some algorithms that we saw in class and potentially run some experiments for that library. There are some other ideas; for example one can implement Shannon’s mind reading machine. More information, as well as papers that people can choose from, will be provided soon.

Examinations

Both the midterm and the final exam will be closed-book written exams in the class where we have our regular meetings.

Collaboration Policy

Regarding homework assignments, unless otherwise specified, students may discuss problem sets with one another. However, students should afterward write the solutions on their own. Collaborators (people you speak to about an assignment) must be named at the top of the assignment. No collaboration will be allowed on exams.

Regarding the course project, students are of course allowed to always work alone. In most cases they will also be allowed to work in pairs, but they need to discuss this with me in advance and make sure that they can indeed work in pairs on a particular project that they have in mind.
Late Work Policy

In general, late work will not be accepted. Problem sets are to be turned in by the end of the class on the day they are due, either in class, or via my mailbox (on the 5th floor of Rice Hall). Any exceptions will be handled on a case-by-case basis; please communicate with me via email in advance.

General Policies by the University of Virginia

UVA is committed to creating a learning environment that meets the needs of its diverse student body. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with me.

Disability Accommodations. If you have a disability, or think you may have a disability, you may also want to meet with the Student Disability Access Center (SDAC), to request an official accommodation. You can find more information about SDAC, including how to apply online, through their website which can be found online at sdac.studenthealth.virginia.edu. If you have already been approved for accommodations through SDAC, please make sure to send me your accommodation letter and meet with me so we can develop an implementation plan together.

Religious Accommodations. It is the University’s long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements. Students who wish to request academic accommodation for a religious observance should submit their request in writing directly to me by email as far in advance as possible. Students and instructors who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University’s Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200. Accommodations do not relieve you of the responsibility for completion of any part of the coursework missed as the result of a religious observance.

Violence and Sexual Assault Prevention. The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that I and the University hold as critically important:

1. Power-based personal violence will not be tolerated.
2. Everyone has a responsibility to do their part to maintain a safe community on Grounds.

If you or someone you know has been affected by power-based personal violence, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available; please see www.virginia.edu/sexualviolence.

As your professor and as a person, know that I care about you and your well-being and stand ready to provide support and resources as I can. As a faculty member, I am a responsible employee, which means that I am required by University policy and federal law to report what you tell me to the University’s Title IX Coordinator. The Title IX Coordinator’s job is to ensure that the reporting student receives the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community. If you would rather keep this information confidential, there are Confidential Employees you can talk to on Grounds (See www.virginia.edu/justreportit/confidential_resources.pdf). The worst possible situation would be for you or your friend to remain silent when there are so many here willing and able to help.

4/5 January 16, 2019
Add/Drop/Withdrawal Deadlines. The School of Engineering has the following deadlines:

Add: January 28
Drop without penalty (course removed from transcript): February 25
Drop with W: March 18

References


