Course Description

This course focuses on developing a theoretical understanding of the statistical properties of learning algorithms. Specific questions we aim to answer throughout the semester include: When do machine learning algorithms work and why? How do we formally characterize the capability of learning algorithms in a probabilistic manner? How do we use insights obtained from theoretical analysis to design better machine learning methods?

Meanwhile, many of the analysis techniques introduced in this class are worth studying in their own right and are useful outside machine learning.

Prerequisites

Probability, linear algebra, basic knowledge of optimization, plus mathematical maturity. This is a theory class: although many tools will be reviewed in lectures, a strong mathematical background is necessary.

Course Webpage

- Canvas: http://canvas.psu.edu

References


Course Outline

1. The PAC learning framework
2. Empirical Risk Minimization
3. Uniform convergence
4. Concentration inequalities
5. Rademacher complexity
6. VC dimension
7. Model selection
8. Support Vector Machine
9. Kernel methods
10. Convex learning and subgradient methods
11. Online learning and bandit problems

The above schedule is subject to change without prior notice.

Course Project

The term project can either be a literature review or include original research.

Literature review. I will provide a list of related papers not covered in the lectures, and the literature review should involve in-depth summaries and exposition of one of these papers.

Original research. It can be either theoretic or experimental (ideally a mix of the two), with approval from the instructor. You are encouraged to combine your current research with your term project.

Project deadlines:

- **Week 9 (Sunday, 03/14, 11:59 PM)** Submit a short proposal (no more than 2 page) stating the topics that you plan to work on. Describe why they are important or interesting, and provide some appropriate references.

- **Weeks 14 & 15** Deliver a 25-minute presentation with slides in class. Focus on high-level ideas, and leave most technical details to your report.

- **Weeks 15 (Friday, 04/30, 11:59 PM)** Submit the final project report.

Project proposal and project reports should be neatly typeset as a PDF document using TeX, LaTeX, or similar systems with bibliographic references (e.g., using BibTeX).

Grading

- Homework Assignments (40%), Take-home midterm (20%), Final project (40%).

- Final project grade consists of three parts: Proposal (5%), Oral Presentation (15%), Final Report (20%)

- There will be three to five homework assignments, approximately one every two weeks. Late homeworks will not be accepted.

- You are welcome to discuss homeworks with other students, but please work out and write up the solutions completely on your own, and specify in your solutions who you’ve discussed which problems with.

<table>
<thead>
<tr>
<th>Score</th>
<th>0, 60</th>
<th>60, 70</th>
<th>70, 77</th>
<th>77, 80</th>
<th>80, 83</th>
<th>83, 87</th>
<th>87, 90</th>
<th>90, 93</th>
<th>93, 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>F</td>
<td>D</td>
<td>C</td>
<td>C+</td>
<td>B-</td>
<td>B</td>
<td>B+</td>
<td>A-</td>
<td>A</td>
</tr>
</tbody>
</table>

Recording of Class Sessions

Video and audio recordings of class lectures will be part of the classroom activity. The video and audio recording is used for educational use/purposes and only may be made available to all students presently enrolled in the class. For purposes where the recordings will be used in future class session/lectures, any type of identifying information will be adequately removed.
Wellness Days

Wednesday, April 7th has been designated as a Wellness Day. No class meeting will happen, either in person or remotely, for that day, and no assignments will be due on that day. Students are encouraged to use the day to focus on their physical and mental health. Please see [https://wellnessdays.psu.edu](https://wellnessdays.psu.edu) for university sponsored events focusing on wellness that may be of interest to you. See Canvas and the course syllabus for any work that may be due before the next class meeting.

Academic Integrity

Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the University's Code of Conduct states that all students should act with personal integrity, respect other students’ dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts.

Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.

Disability Accommodation Statement

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus ([http://equity.psu.edu/sdr/disability-coordinator](http://equity.psu.edu/sdr/disability-coordinator)). For further information, please visit Student Disability Resources website ([http://equity.psu.edu/sdr/](http://equity.psu.edu/sdr/)).

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines ([http://equity.psu.edu/sdr/guidelines](http://equity.psu.edu/sdr/guidelines)). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling and Psychological Services Statement

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Counseling and Psychological Services at University Park (CAPS) ([http://studentaffairs.psu.edu/counseling/](http://studentaffairs.psu.edu/counseling/)): 814-863-0395

Counseling and Psychological Services at Commonwealth Campuses ([https://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/](https://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/))

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400

Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741
Educational Equity and Reporting Bias

Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harassment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the Report Bias webpage (http://equity.psu.edu/reportbias/).

Copyright Statement

All course materials students receive or to which students have online access are protected by copyright laws. Students may use course materials and make copies for their own use as needed, but unauthorized distribution and/or uploading of materials without the instructors express permission is strictly prohibited. University Policy AD 40, the University Policy Recording of Classroom Activities and Note Taking Services addresses this issue. Students who engage in the unauthorized distribution of copyrighted materials may be held in violation of the Universitys Code of Conduct, and/or liable under Federal and State laws.