USC Viterbi School of Engineering

Course ID and Title:
EE 599 Data-Driven Optimization and Control
Units: 3
Term—Day—Time: Fall 2017, TuTh, 5:00-6:20

Location: TBD

Instructor: Insoon Yang
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Office Hours: TuTh, 4:00-5:00
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Teaching Assistant: N/A
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IT Help: N/A
Hours of Service: N/A
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Course Description

Various critical decision-making and control problems associated with engineering and socio-technical systems are subject to uncertainties. Massive data collected from the Internet of Things and cyber-physical systems can provide information about the probability distribution of these uncertainties. Furthermore, in many practical problems, the distribution of unobservable states can be efficiently estimated from data about observed variables using statistical learning and filtering methods. Such distributional information can be used to dramatically improve the quality of decision-making if we adopt appropriate analytical and computational tools. However, several concerns have been raised about how best to incorporate the collected data into decision-making and control problems. These concerns center on robustness, safety, risk and reliability because the data and statistical models extracted from the data often result in inaccurate distributional information. This course provides advanced optimization and control methods to resolve these issues by allowing distributional errors in statistical models and by providing decision-making strategies that are robust against these errors.

Learning Objectives

In the first part of this course, students will learn a fundamental data-driven stochastic programming model called *distributionally robust optimization*. This model is useful for one to make decisions that are robust against distributional errors in data and statistical models. However, this is an infinite-dimensional minimax optimization problem, which is computationally challenging. To resolve this issue, we will study tractable reformulation and approximation methods by mainly using strong duality. The second part will cover extensions to control problems. Students will learn distributionally Markov decision processes and stochastic control methods with an emphasis on safety specifications and risk management. In the last part, online convex optimization models and algorithms (e.g., regret minimization) will be covered.

Prerequisite(s): EE 441, EE 503
Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: EE 588, EE 556

Course Notes

Letter Grade; Lecture slides and other class information will be posted on Blackboard.

Technological Proficiency and Hardware/Software Required

Python or MATLAB

Required Readings and Supplementary Materials

This course is based on research papers that are specified in Course Schedule.

Description and Assessment of Assignments

Homework assignments mostly consist of analytical and numerical problems that help one digest course materials. In each assignment, there will be one or two research oriented problems to stimulate students' creativity.

Each individual student must perform a research project. Examples of relevant topics will be announced in Week 2. Each student must have a meeting with the instructor about his or her project idea and plan in Weeks 4 and 5. Abstract submission is due in Week 7. Project reports must be submitted in Week 15. Each student will give a 20 min talk about his or her project in the final week.

Grading Breakdown

Including the above detailed assignments, how will students be graded overall? Participation should be no more than 15%, unless justified for a higher amount. All must total 100%.

Assignment	Points	% of Grade
Homework	40	40
Participation	10	10
Final project	50	50
TOTAL	100	100

Assignment Submission Policy

Working in groups is encouraged. However, each person must submit his/her own problem sets. Problem sets are due by 5PM in a box in front of Prof. Yang's office, EEB 316. Late submissions will not be accepted.

Grading Timeline

One week after submission.

Additional Policies

Attendance of the lectures is expected.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	Course overview and motivation		
Week 2	Decision models under ambiguous distributional information about uncertainties (distributionally robust optimization)	Scarf, H., 1958. Dupacova, J., 1987.	
Week 3	Distributionally robust optimization with moment constraints	Delage, E. and Ye, Y., 2010.	
Week 4	Distributionally robust optimization with chance constraints	Calafiore, G. C. and El Ghaoui, L., 2006. Zymler, S. et al., 2013.	HW#1 assigned Project meetings
Week 5	Approximation methods	Goh, J. and Sim, M., 2010.	Project meetings
Week 6	Distributionally robust convex optimization via lifting	Wiesemann, W. et al., 2014.	HW#1 due
Week 7	Distributionally robust optimization with statistical distances I: phi-divergence	Bayraksan, G. and Love, D. K., 2015.	HW#2 assigned Project abstract due
Week 8	Distributionally robust optimization with statistical distances II: Wasserstein distance	Gao, R. and Kleywegt, A. J., 2016.	
Week 9	Distributionally robust MDP with moment constraints	Xu, H. and Mannor, S., 2012. Yu, P. and Xu, H., 2016.	HW#2 due
Week 10	Distributionally robust MDP with statistical distances		HW#3 assigned
Week 11	Distributionally robust linear quadratic control	Van Parys, B. P. G. et al., 2016.	
Week 12	Distributionally robust optimal control and safety specifications	Yang, I., 2017.	HW#3 due
Week 13	Online linear programming	Agrawal, R. et al., 2014.	HW#4 assigned
Week 14 (Thanksgiving)	Online convex optimization I	Shalev-Shwartz, S., 2011. Hazan, E., 2016.	
Week 15	Online convex optimization II	Agrawal, S. and Devanur, N. R., 2015.	HW#4 due Project report due
FINAL	Project presentation		

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" https://policy.usc.edu/student/scampus/part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, intimate partner violence, stalking, and harassment are prohibited by the university. You are encouraged to report all incidents to the *Office of Equity and Diversity*/*Title IX Office* http://equity.usc.edu and/or to the *Department of Public Safety* http://dps.usc.edu. This is important for the health and safety of the whole USC community. Faculty and staff must report any information regarding an incident to the Title IX Coordinator who will provide outreach and information to the affected party. The sexual assault resource center webpage http://sarc.usc.edu fully describes reporting options. Relationship and Sexual Violence Services https://engemannshc.usc.edu/rsvp provides 24/7 confidential support.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://ali.usc.edu, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://dsp.usc.edu provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* http://emergency.usc.edu will provide safety and other updates, including ways in which instruction will be continued by means of Blackboard, teleconferencing, and other technology.