TEL AVIV UNIVERSITY אוניברסיטת תל-אביב
THE IBY AND ALADAR FLEISCHMAN FACULTY OF ENGINEERING
הפקולטה להנדסה
על שם איבי ואלדר פליישמן

Learning to Control

Fall 2021–2022

Instructor: Anatoly Khina, 03-640-7195, anatolyk@tauex.tau.ac.il

Time: Wednesday, 4–6 PM.

Method: Hybrid in-person/online lectures. Zoom.

- Classroom: 008 EE-Classrooms.
- All lectures will be recorded and made available online.

Prerequisite: Introduction to Modern Linear Control.

Grading policy: homework assignments (15%), student lecture (40%), final project (35%), active participation in class (10%).

Course Objectives: Adaptive control and system identification are well established fields within the discipline of control theory. Recent developments in learning theory provide new view and tools for the study and treatment of these fields. In this course, we will start by presenting the classical problem of control, review fundamental classical control methods when the system is known, as well as for the adaptive control and system identification setups. We will then study data-driven methods from learning theory that aim to minimize the regret. This is a mathematically-oriented course.

Tentative Course Topics: *This is an advanced graduate-level course seminar. The following is a list of possible topics that will be covered during this course.*

- **Introduction:** The control problem, adaptive control, machine learning control.
- **Modern linear control theory recap:** Kalman filter, linear quadratic regulator (LQR), linear quadratic Gaussian (LQG) control, H_2 vs. H_∞ control.
- **System identification:** Classical techniques for parameter learning.
- **LQR coefficient learning:** Adaptive/online LQR setting with unknown (A, B) matrices.

- *Non-stochastic control:* Adversarial disturbances.
- **Causal-regret optimal control:** Minimizing the MMSE/control cost compared to a non-causal estimator/controller.
- **Different costs:** convex costs, logarithmic costs, etc.

Main References

[1] *Selected papers (see topics for final project).*

[2] D. P. Bertsekas, *Dynamic Programming and Optimal Control*, 3rd ed. Belmont, MA, USA: Athena Scientific, 2007, vol. I and II.

[3] K. J. Åström, *Introduction to Stochastic Control Theory.* New York, NY, USA: Academic Press, 1970, vol. 70.

[4] M. A. Dahleh and I. J. Diaz-Bobillo, *Control of Uncertain Systems: A Linear Programming Approach.* Upper Saddle River, NJ, USA: Prentice-Hall, 1995.

[5] T. Kailath, A. H. Sayed, and B. Hassibi, *Linear Estimation.* Prentice Hall, 2000.

[6] B. Hassibi, A. H. Sayed, and T. Kailath, *Indefinite-Quadraric Estimation and Control: A Unified Approach to H2 and H-infinity Theories.* New York: SIAM Studies in Applied Mathematics, 1998.