University of Kurdistan
Department of Electrical Engineering

Optimal Control

(Fall 2019)

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Course Description

In many practical control problems, it is desired to optimize a given cost function while satisfying constraints involving dynamical systems. These kinds of systems typically fall into area of optimal control, a centerpiece of modern control theory. Optimal control methods comprise fundamental tools used in many engineering systems such as economics and logistics, aerospace systems, automotive industry, autonomous systems and robotics, bio-engineering, process control, and power systems. The objective of the course is to familiarize the students with the theory and application of optimal control for linear and nonlinear systems.

Topics Covered

1. Introduction to optimal control
2. Roots in the calculus of variations
3. Dynamic programming
4. Pontryagin minimum principle (PMP)
5. Linear quadratic control
6. Model predictive control (MPC)
7. Applications

Grading

The course grade will be determined using the following:

- Homework and Activities: 15%
- Presentation of a Recent Work: 15%
- Final Exam: 35%
- Final Project: 35%

References

[1] Q. Shafiee, *Course Lecture Notes*, Spring 2019.

[2] D. S. Naidu, *Optimal Control Systems*, CRC Press, 2002.

[3] D. E. Kirk. *Optimal Control Theory: An Introduction.* Prentice-Hall, 2004.

[4] Daniel Liberzon, *Calculus of Variations and Optimal Control: A Concise Introduction*, Princeton University Press, 2012.

[5] Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, *Optimal Control*, 3rd Edition, Wiley, 2012.

Overview papers

- R. W. H. Sargent. "Optimal Control", *Journal of Computational and Applied Mathematics*, vol. 124, pp. 361-371, 2000.
- H. J. Sussmann, J. C. Willems, "300 years of optimal control: from the brachystochrone to the maximum principle." *IEEE Control Systems Magazine*, vol. 17, no. 3, pp. 32-44, 1997.

Homework Assignments

Throughout the course the students will have to solve a number of home assignments. The solutions are presented at home assignment seminars where, for each problem, one of the students is chosen at random to present his/her solution on the whiteboard. The homework assignments will be performed along the semester.

Note: Students may discuss the problems with other students, but they are not allowed to share solutions (MATLAB m-files, etc.).

Final Project

Number of recent published IEEE Transactions in the field of Optimal Control will be provided. You can choose among them and work on a paper of your choice. You must make sure that you do not choose the same topic as the other students. During the last 1/2 of this course, you will present the selected paper. This will give you a chance to deepen your knowledge in your area of interest. Around 10 minutes is given to each student to present his/her project-work to the rest of the class.

For the final project, you should either regenerate the paper (using simulation in Matlab) or use the problem stated in the paper, and try to improve the drawbacks of the work using the knowledge you earn during the course. Finally, you should provide a detailed written report and sent it to q.shafiee@uok.ac.ir. You may be asked to present your work in person in case needed.