The University of Texas at Austin
Department of Aerospace Engineering and Engineering Mechanics
ASE 389: Networked Control Systems
Spring 2024 Syllabus

Unique number: 14263
Time: MW 12:30 p.m. – 2:00 p.m.
Room: ASE 2.134

Instructor:

Dr. Takashi Tanaka (ASE 4-230),
Email: ttanaka@utexas.edu
Office hours: Wednesdays 10:30 a.m. – Noon.
There will be no teaching assistants.

Course webpage:

Canvas – http://canvas.utexas.edu

Textbook:

- T. M. Cover and J. A. Thomas. *Elements of Information Theory*. 2nd Edition Wiley, 2006.

Additional References:

- S. Yüksel and T. Başar, *Networked control systems Stochastic Networked Control Systems: Stabilization and Optimization under Information Constraints*. Springer, 2013.
- B. Øksendal, *Stochastic differential equations*. Springer, 2003.

Course Objectives:

Networked Control Systems (NCSs) are feedback control systems that operate over a variety of communications networks. These systems are already ubiquitous in today's society and are expected to become even more prevalent with the emergence of new technologies and applications, such as connected cars and delivery drones, as well as the increasing use of cloud-based control. The theory behind NCS is especially important when designing reliable control systems over unreliable or resource-constrained networks.

This course first covers specific topics in information theory crucial to the design and analysis of NCSs. Team decision theory and key results in distributed control will be discussed. These concepts are then applied to derive notable results in NCS theory, such as data rate theorems, minimum information control, and event-based control. Additionally, this year's curriculum includes selected topics in cyber-physical security of NCSs.

The objective of this course is to familiarize students with both foundational theory and cutting-edge advancements in NCS research through homework assignments and in-class research projects.

Prerequisites:

Fundamentals of linear systems theory (ASE 330 or equivalent) and feedback control theory (ASE 370 or equivalent) will be essential. Basic probability theory will be helpful, but is not strictly required.

Schedule:

Lecture	Date		Topic
1	1/17		Introduction
2	1/22	Part I: Stochastic control	Optimal Control and MDPs
3	1/24		Optimal Control and MDPs
4	1/29	Part II: Information theory	Entropy
5	1/31		Mutual information
6	2/5		Asymptotic equipartition property
7	2/7		Data compression
8	2/12		Differential entropy
9	2/14		Rate-distortion theory
10	2/19	Part III: Team theory	Static team
11	2/21		Dynamic team
12	2/26		Witsenhausen's counterexample
13	2/28		Distributed control
14	3/4		Distributed control
15	3/6	Part IV: Control over communication channels	Data-rate theorem
16	3/18		Remote estimation
17	3/20		Minimum-information control
18	3/25		Minimum-information control
19	3/27		Event based control
20	4/1		Event based control
21	4/3		Review
22	4/8		**Midterm presentation**
23	4/10	Part V: CPS security	Overview
24	4/15		Replay and data injection attacks
25	4/17		Hypothesis testing
26	4/22		Anomaly detection
27	4/24		Review
28	4/29		**Final presentation**

Grading:

The final grade will be calculated based on homework assignments (60 points total), final project (40 points) and attendance (10 points). Grades are determined based on the following rule: A (93-110), A- (90-92), B+ (87-89), B (83-86), B- (80-82), C+ (77-79), C (73-76), and C- (70-72). The extra 10% is granted to all students to accommodate unexpected events such as medical emergency.

Homework:

There will be (almost) biweekly homework assignments during the semester. Each assignment and its due date will be posted on Canvas. No late homework will be accepted unless prior permission in exceptional circumstances has been granted. Collaboration is allowed. In case of collaboration, each

student should return her/his work along with a statement that clearly indicates her/his collaborators and her/his role in the resulting work.

Attendance:

Regular attendance is expected and strongly recommended. Throughout the semester, the students are expected to engage through discussions in class and during office hours. All the classes will be recorded on zoom; however the lecture videos will be released only for students who missed the class for justifiable reasons. Absence must be notified in advance.

Final project:

Students are expected to complete individual mini-research projects by the end of the semester. Each project should involve a numerical implementation of an algorithm related to NCSs. Grades are based on mid-semester presentations, final presentations, and final report. Further details will be provided in the lecture.

Computer usage:

There will be homework assignments that require the use of MATLAB.

Accessible, Inclusive, and Compliant Statement:

The university is committed to creating an accessible and inclusive learning environment consistent with university policy and federal and state law. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Services for Students with Disabilities (SSD). Please refer to SSD's website for contact and more information: http://diversity.utexas.edu/disability/. If you are already registered with SSD, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

Sharing of Course Materials is Prohibited:

No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings:

Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

Prepared by: Takashi Tanaka Date: 1/9/2024