AE 8803: Intelligent Cyber-Physical Systems

Course Syllabus

Instructor: Prof. Kyriakos G. Vamvoudakis

Dept.: The Daniel Guggenheim School of Aerospace Engineering
Office: Knight Building 415-B

Phone: 385-3342

E-mail: kyriakos@gatech.edu

Web: http://kyriakos.ae.gatech.edu/

Time & Location: MW 3:30pm-4:45pm Instr. Center 209 (Mostly online)

Office Hours: MW 3:00pm-5:00pm Bluejeans

These are the "formal" office hours. However, you are more than welcome to stop by my office any time, should you have any questions regarding the course material. Additionally, appointments can be arranged to discuss any questions regarding the course material. The easiest way to reach me is, however, via e-mail.

Course Web Page: All relevant information on the class will be disseminated electronically at canvas.

Required Texts: There is no required text. The instructor will provide notes and research papers.

Prerequisites: Undergraduate linear algebra, probability and signal processing, understanding of modern (state space) control theory

Required Software: Student Edition of Matlab

Course Description and Topics: In this course, we will review several recent advancements in cyber-physical systems and intelligent control. Topics will include core principles of CPS, differential equations to model physical processes, graph theory and CPS communication structures, control loops in CPS, intelligent control, game theoretic frameworks for secure control, control and estimation over lossy and attacked networks, intrusion and fault detection in CPS, differential and temporal logic for safety of execution, machine learning in CPS.

Course Topics:

I. Introductory Topics
II. CPS Communication Structures
III. Cooperative Control Loops and Importance of Control and Actuation in CPS
IV. Intelligent Hybrid Control
VI. Secure Control
VII. Control and Estimation over Lossy and Attacked Networks
VIII. Intrusion Detection and Fault Detection in Cyber-Physical Systems
IX. Differential and Temporal Logic
X. Topics on Machine Learning and CPS

Tentative Grading Policy
Tentative Grading: Homework and Paper Presentations 25%-Midterm Project 35%-Final Project 40%

Student Learning Outcomes:

1. Understand control and shared resources in cyber-physical systems.

   Assessment- homework design projects.

2. Understand the basic different types of graphs that dictate the flow of information.

   Assessment- homework design projects and examinations.

3. Ability to perform designs with various tools using MATLAB.

   Assessment- design and simulation projects assigned in homework.

4. Understand control over adversarial and "lossy" networks.

   Assessment- design and simulation projects in homework.

5. Understand intrusion detection and identification.

   Assessment- design and simulation projects in homework, exams.

6. Learn to perform a literature search and prepare a research paper with a unified presentation and exposition on a selected topic.

   Assessment- Final Project Report.

Homework Assignments:

- Due at the beginning of the class on the due date. Solutions to the homework will be posted on the web at the time that they are due. Therefore, NO LATE HOMEWORK will be accepted.
- Electronic submissions will be accepted before the class starts.
- Late homework will not be accepted without formal documentation of extenuating circumstances (e.g. a note from a Dean, a physician, etc.).

Course Policies: 1. NO CELL PHONES are allowed during lecture. 2. Be on time to class. Tardy is discouraged. 3. No make-up exams/quizzes. If you miss the exam, a zero score will be assigned to the missed exam/quiz. 4. If you miss a class due to personal emergency or medical reasons, please be sure to inform the instructor by e-mail. 5. Homework assignments are to be submitted by the due date. You may discuss homework problems with your classmates, but you are responsible for your own works. 6. After an assignment grade has been posted online, students must see the instructor within one week if they wish to discuss the assignment and their work.

Principles of Community: Students are expected to be polite and professional when interacting with one another and with the instructor. Abusive or insensitive behavior will not be tolerated.

Academic Support: The instructor will provide assistance through normal protocols, such as office hours, but cannot serve as a private tutor.

Special Accommodations: Special accommodations can be made for students with disabilities. Please bring any such issues to the instructor's attention *no later than the second week of class*.

Health and Well-Being: Georgia Tech and the School of Aerospace Engineering understand that many students experience stress through a variety of academic, financial and personal experiences. We value you and want to make you aware of resources available to you should you need them. Your well-being and mental health are important, and we are here for you.

Center for Assessment, Referral and Education (CARE)		https://care.gatech.edu/
Campus Police (any emergency):	404-894-2500	http://www.police.gatech.edu/
Counseling Center:	404-894-2575	https://counseling.gatech.edu/
Dean of Students Office:	404- 894-6367	https://studentlife.gatech.edu/
Georgia Crisis and Access Line:	800-715-4225	

National Suicide Prevention Lifeline: 800-273-TALK (8255) https://suicidepreventionlifeline.org/

Crisis Text Line: Text HOME to 741741

VOICE: Victims Survivor Support: (404) 385-4464 (or 4451) http://healthinitiatives.gatech.edu/well-being/voice

Stamps Health Services https://health.gatech.edu/contact

Tentative Roadmap			Spring 2021 (AE 8803)	
Number of Lecture	date	day	Topic	Reading Assignments
1	20-Jan	wed	Introduction to CPS	-
2	25-Jan	mon	Differential Equations as Models of Physical Processes (Physical Part)	-
3	27-Jan	wed	Graph Theory and Communication Structure in CPS (Cyber Part)	-
4	1-Feb	mon	Graph Theory and Communication Structure in CPS (Cyber Part)	-
5	3-Feb	wed	Graph Theory and Communication Structure in CPS (Cyber Part)	Provided Research Papers
6	8-Feb	mon	Graph Theory and Communication Structure in CPS (Cyber Part)	Provided Research Papers
7	10-Feb	wed	Control Loops and Importance of Control and Actuation in CPS	-
8	15-Feb	mon	Control Loops and Importance of Control and Actuation in CPS	Provided Research Papers
9	17-Feb	wed	Control Loops and Importance of Control and Actuation in CPS	Provided Research Papers
10	22-Feb	mon	Invariant Synthesis	-
11	24-Feb	wed	Invariant Synthesis	Provided Research Papers
12	1-Mar	mon	Invariant Synthesis	-
13	3-Mar	wed	Validation	Provided Research Papers
14	8-Mar	mon	Secure Cooperative Control	Provided Research Papers
15	10-Mar	wed	Secure Cooperative Control	Provided Research Papers
16	15-Mar	mon	Control and Estimation over Lossy and Attacked Networks	Provided Research Papers
17	17-Mar	wed	Control and Estimation over Lossy and Attacked Networks	Provided Research Papers
18	22-Mar	mon	Intrustion Detection and Fault Detection in CPS	Provided Research Papers
19	24-Mar	wed	No class	-
20	29-Mar	mon	Differential and Temporal Logic for Safety of Execution of CPS	Provided Research Papers
21	31-Mar	wed	Differential and Temporal Logic for Safety of Execution of CPS	-
22	5-Apr	mon	Differential and Temporal Logic for Safety of Execution of CPS	-
23	7-Apr	wed	Differential and Temporal Logic for Safety of Execution of CPS	Provided Research Papers
24	12-Apr	mon	Differential and Temporal Logic for Safety of Execution of CPS	Provided Research Papers
25	14-Apr	wed	Topics on Machine Learning and CPS	Provided Research Papers
26	19-Apr	mon	Topics on Machine Learning and CPS	Provided Research Papers
27	21-Apr	wed	Topics on Machine Learning and CPS	Provided Research Papers
28	26-Apr	mon	Project Presentations	-