SE733/EC733/ME733: *DISCRETE EVENT AND HYBRID SYSTEMS*

SPRING 2024

(4 credits)

Professor Christos G. Cassandras

PHO (8 St. Mary's St.), Room 425,

TEL: 353-7154, **E-MAIL:** *cgc@bu.edu*, **WWW:** *https://christosgcassandras.org/*

• Organization: Lectures: M,W 12:20-2:05PM, EMB 105

• Prerequisites: EK 500 or equivalent; SE501 or equivalent

• Requirements:

1. Homework Assignments and Class Presentations	30%
2. Course project and report	70%

• Objectives:

1. Learn about Discrete Event Systems (**DES**) and Hybrid Systems (**HS**) that combine both continuous (time-driven) and discrete (event-driven) dynamics, giving rise to **Cyber-Physical Systems** (**CPS**) and applications to areas such as multi-agent systems, communication and sensor networks, IoT, robotics, manufacturing, transportation.

2. Learn about **data-driven learning** methodologies for the control and optimization of these systems.

3. Develop the ability to conceptualize cutting-edge issues in the **Cyber-Physical Systems** domain, and formulate problems for potential research purposes.

• Office Hours: Monday, 2:15-3:15pm.

• Required Books: Cassandras, C.G., and Lafortune, S., *Introduction to Discrete Event Systems*, 3rd Edition, Springer, 2021.

• COURSE OUTLINE •

1. Review of system theory fundamentals and Cyber-Physical Systems.

2. Untimed DES Models: Automata, Petri Nets

3. Timed Models: Timed Automata, Timed Petri Nets, max-plus algebra models

4. Monte Carlo computer simulation: principles, pitfalls, applications using commercial software tools (e.g., SimEvents see http://www.mathworks.com/products/simevents/)

5. Stochastic models, queueing theory

6. Markov Decision Process theory

7. Perturbation Analysis and Rapid Learning methods; applications to Cyber-Physical Systems (traffic control, autonomous driving, smart cities, etc)

8. Hybrid Systems: Hybrid Automata, Mixed Logical Dynamical systems, Stochastic Flow Models and how they apply to Cyber-Physical Systems

9. Introduction to the analysis and control of Hybrid Systems

• ADDITIONAL REFERENCES •

- Baccelli, F., G. Cohen, G.J. Olsder, and J.-P. Quadrat, "Synchronization and Linearity: An Algebra for Discrete Event Systems", Wiley, Chichester, 1992.
- Ho, Y.C., and X. Cao, "Perturbation Analysis of Discrete Event Dynamic Systems", Kluwer Academic Publishers, Boston, 1991.
- Law, A.M., and W.D. Kelton,"Simulation Modeling and Analysis", McGraw-Hill, New York, 1991.
- Ross, S.M., "Introduction to Stochastic Dynamic Programming", Academic Press, New York, 1983.
- *Proceedings of the IEEE*, Special Issue on Hybrid Systems, (P. Antsaklis, Ed.), Vol. 88, 7, 2000.

- Cassandras, C.G, and Lygeros, J., (Ed's), "Stochastic Hybrid Systems", CRC Press, 2007.
- Alur, R., "Principles of Cyber-physical Systems", MIT Press, 2015.
- **State-of-the art papers to be handed out in class**