Fall 2018
Updated March 16 2018

AEROSP 540 (MECHENG 540) [Orosz] Intermediate Dynamics
AEROSP 548 [Kolmanovsky] Astrodynamics
AERO 550 (EECS 560) (ME 564) (CEE 571) [Gillespie] Linear System Theory
AERO 566 [Bernstein] Data Analysis and System Identification
AERO 584 [Panagou] Navigation and Guidance of Aerospace Vehicles
AERO 740 [Gorodetsky] Parameter Inference and State Estimation
AERO 740 [Girard] Applied Nonlinear Control

CEE572 [Lynch] Dynamical Infrastructure Systems

EECS 418 [Alvestruz] Power Electronics
EECS 460 [Meerkov] Control system analysis and design
EECS 461 [Freudenberg] Embedded control
EECS 463 [Mathieu] Power systems design and operation
EECS 498-006 [Berenson] Intro to Algorithmic Robotics
EECS 560 (AERO 550) (ME 564) [Gillespie] Linear System Theory
EECS 563 [Ozay] Hybrid Systems: Specification, Verification and Control
EECS 566 [Lafortune] Discrete Event Systems
EECS 567 (ME 567) [Jenkins] Robot Kinematics and Dynamics
EECS 598-008 [Hiskens] Power systems dynamics and control
EECS 600 (IOE 600) [Balzano] Function Space Methods in System Theory

ME 461 [Rouse] Automatic Control
ME 540 [Orosz] Intermediate Dynamics
ME 560 [Stein] Modeling Dynamical Systems
ME 564 (AERO 550) (EECS 560) [Gillespie]
ME 567 (EECS 567) [Jenkins] Robot Kinematics and Dynamics
ME 569 [Stefanopoulou] Advanced Powertrain Systems
ME 599 (ROB 535) (NAME 565) [Johnson-Roberson, Vasudevan] Self-driving cars: Perception and Control

ROB 501 [Grizzle] Mathematics for Robotics
ROB 535 (ME 599) (NAME 565) [Johnson-Roberson, Vasudevan] Self-driving cars: Perception and Control
ROB 550 [Revzen, Gaskell] Robotics Systems Laboratory

Interesting IOE courses
IOE 510 - Linear Programming I
IOE 610- Linear Programming II
IOE 611- Nonlinear Programming

F18 Control-Related Grad Courses in the Aerospace Department

AE548: Astrodynamics (MW, 2:30-4:00)
Instructor: Professor I. Kolmanovsky
Synopsis: Students will learn about the two-body problem for spacecraft, orbital trajectories, orbital maneuvers and transfers, and modeling and characterization of gravitational and non-gravitational forces acting on the spacecraft. Additional topics include: orbit perturbation models, the restricted 3-body problem, Lagrange points, and Halo orbits. Finally, I will introduce orbit determination and estimation based on measurements.

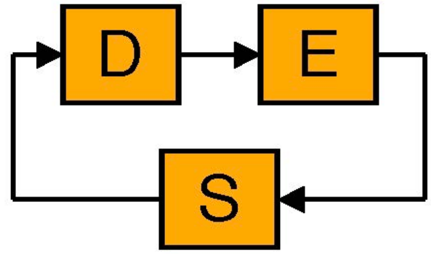
AE566: Data Analysis and System Identification (TTh, 8:00-9:30)
Instructor: Professor D. S. Bernstein
Synopsis: Students will learn about the theory and algorithms for constructing linear and nonlinear models from noisy input-output data. The course will present and analyze identification methods for state space and input-output models in the time and frequency domains. Statistical measures of performance such as consistency (asymptotic unbiasedness) will be discussed. For the final project, students will apply the techniques they learn to real data sets. PhD students are encouraged to analyze and fit data from their experimental or computational studies.

AE584: Guidance and Navigation of Aerospace Vehicles (MW, 11:30-1:00)
Instructor: Professor D. Panagou
Synopsis: The course covers theory and algorithms for aerospace navigation and guidance. The students are introduced to the mathematical concepts and principles that guide the use of uncertain data in order to solve the navigation problem ("Where is the vehicle? What is its velocity and orientation?") and the guidance problem ("What maneuvers to perform so that the vehicle moves where we want along with mission specifications?"). The course covers the fundamental properties of deterministic linear systems, elements of probability theory and random processes, estimation methods (Observers, Kalman filters, Maximum Likelihood), and their application to aircraft/spacecraft navigation and missile guidance.

AE740: Parameter Inference and State Estimation (TTh, 11:30-1:00)
Instructor: Professor A. Gorodetsky
Synopsis: Parameter inference and state estimation covers theory and algorithms for combining models and data in engineering systems. Topics will include algorithms for maximum likelihood estimation, Bayesian inference, and regression for static inference problems and for estimation in dynamical systems. The first part of this course will focus on parameter inference and include recent advances in Monte Carlo sampling, importance sampling, and Markov chain Monte Carlo (MCMC). The second part of the course will cover state estimation and include particle filters and variants of Kalman filters such as the extended, ensemble, unscented, and Gauss-Hermite filters. Theoretical foundations of the algorithms will be described and practical experience will be gained through projects that focus on implementation. PhD students will be encouraged to work on inference and estimation problems relevant to their ongoing research.

AE740: Applied Nonlinear Control (TTh, 10:00-11:30)
Instructor: Professor A. Girard
Synopsis: General properties of linear and nonlinear systems, phase plane analysis, equilibrium finding. Qualitative analysis of nonlinear systems and the center manifold theorem. Controllability and observability of nonlinear systems. Stability of nonlinear systems. Feedback linearization. Sliding control theory. Nonlinear observers. Time permitting, distributed control and aspects of differential games.

Course Announcement FALL 2018



EECS 566 DISCRETE EVENT SYSTEMS

Instructor: Stéphane Lafortune
Room 4415 EECS
stephane@umich.edu ; www.eecs.umich.edu/~stephane

Time: Tuesday-Thursday: 3:00 pm to 4:30 pm (1017 Dow)

Prerequisite: Graduate standing in ECE, CSE, or any CoE grad program

Description: 566 is offered in the fall semesters of *even* years

This course is intended for engineering and computer science graduate students who want to learn about dynamic systems with discrete state spaces and event-driven transitions. Discrete Event Systems, as they are called, arise in the modeling of technological systems such as automated manufacturing systems, process control systems, software systems, transportation systems, and more generally autonomous systems with a supervisory control layer. In embedded and networked systems, discrete event dynamics are coupled with continuous dynamics, giving rise to what are called Hybrid Systems or Cyber-Physical Systems (CPS).

This course will introduce students to the modeling, analysis, and control of Discrete Event Systems (DES). The primary emphasis will be on the logical, or untimed, behavior of DES (i.e., high level behavior of CPS) and will encompass modeling formalisms (automata and Petri nets), verification techniques, fault diagnosis, and supervisory control problems. Timed automata will also be introduced, as an example of hybrid systems. Examples from the above areas will be used throughout the course to illustrate the main concepts. Various software tools will be used in the course.

There are no specific course prerequisites. EECS 566 is also open to undergraduate seniors, but they should consult with the instructor first.

(See over for more details)

Textbook: "Introduction to Discrete Event Systems - Second Edition" by C. Cassandras and S. Lafortune, Springer, 2008.

Grading: Homework assignments, one midterm exam, and a final exam.

Syllabus: Chapters 2, 3, 4, and 5 of textbook.

- Finite-state automata models of DES. Notions of deadlock and livelock; product and parallel composition; observer and diagnoser automata; analysis of safety and liveness properties. Event diagnosis

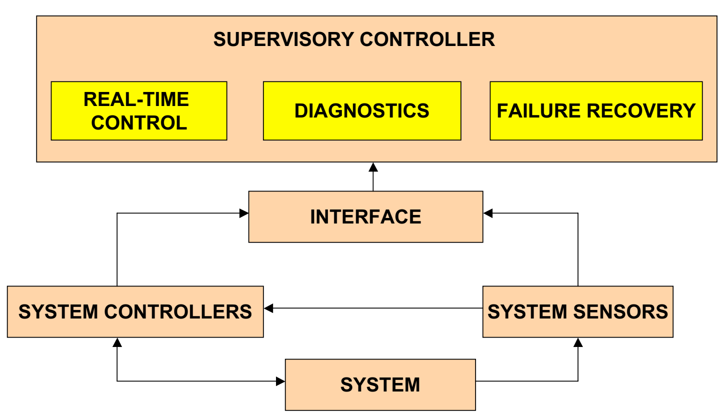
- Petri net models of DES. Reachability analysis with coverability tree; structural analysis using incidence matrix

- Supervisory control of systems modeled by automata. Notions of controllability and observability for DES; control under full and partial observation; nonblocking control. Synthesis algorithms for partial-observation supervisors

- Supervisory control of Petri nets by monitor places

- Timed automata models of DES. Parallel composition; reachability analysis by untiming

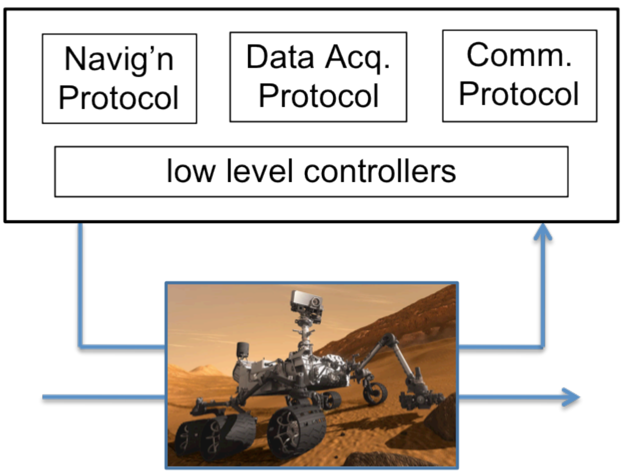
- Brief introduction to hybrid automata models of hybrid systems



EECS 563

Hybrid Systems: Specification, Verification and Control

$$\varphi_{\text{env}} \rightarrow (\varphi_{\text{nav}} \wedge \varphi_{\text{dac}} \wedge \varphi_{\text{com}})$$



$$\dot{x} = f(x, u)$$

Hybrid systems, dynamical systems where continuous dynamics and discrete events interact, are ubiquitous and can be found in many different contexts. Examples are as diverse as manufacturing processes, biological systems, energy systems, medical devices, robotics systems, automobiles and aircrafts. Advances in computing and communication technologies have enabled engineering such systems with a high degree of complexity. Most of these systems are safety-critical, hence their correctness must be verified before they can be deployed.

This course will provide a working knowledge of several analysis and design techniques to guarantee safety, reliability and performance of such systems.

Topics include

- specifications: Automata theory, discrete transition systems, temporal logics
- modeling: Hybrid automata, switched systems, piecewise affine systems
- verification of hybrid systems: stability, model checking, direct methods (barrier certificates, reachability analysis), abstraction-based methods
- optimization basics for control system analysis and design: convex geometry, convex optimization, sum-of squares
- correct-by-construction controller synthesis: reactive control synthesis, switching protocols, hybrid model-predictive control

and more…

Grading will be based on a few homework assignments, critiquing research papers and in-class discussions, and a (team) term project.

Instructor: Necmiye Ozay, EECS
For additional information contact necmiye@umich.edu
web.eecs.umich.edu/~necmiye/courses/hybridsystems.html