University Of California, Berkeley
Department of Mechanical Engineering

ME 230A – Predictive Control - 2 units

Graduate Course

Syllabus

CATALOG DESCRIPTION

Advanced optimization, polyhedra manipulation, and multiparametric programming. Robust Invariant set theory. Analysis and design of model predictive controllers (MPC) for linear and nonlinear systems. Stochastic MPC. Learning MPC. Computational oriented models of hybrid systems. Analysis and design of constrained predictive controllers for hybrid systems.

COURSE PREREQUISITES

ME C232 and ME C231A

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Online Free and Open Source Resources

COURSE OBJECTIVES

The course is designed for graduate students who want to expand their knowledge on model predictive control. 80% will be focusing on advanced theory. 20% on applications.

DESIRED COURSE OUTCOMES

At the end of the course, the students will write a theoretical paper on MPC and/or will design an application where the advanced theory is implemented.

TOPICS COVERED

Advanced optimization, polyhedra manipulation, and multiparametric programming. Robust invariant set theory. Analysis and design of model predictive controllers (MPC) for linear and nonlinear systems. Stochastic MPC. Learning MPC. Computational oriented models of hybrid systems. Analysis and design of constrained predictive controllers for hybrid systems.

CLASS/LABORATORY SCHEDULE

2-unit courses (90 hour workload)
2 hr instruction/week, weeks #1-10
1 hr exam (5 hr prep)
4 hr HW/week, weeks #1-10
1 hr project work, weeks #1-10
8 hr project work/wk, weeks #11-12

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

Optimization-based control design is highly requested skill from a number of industries, including automotive, aerospace, process control and manufacturing. The course will provide the students with a solid theoretical background needed for hi-tech industries, as well as with tools for implementing optimization-based control design.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

10% Homework
60% Final Exam
30% Final Project

TOPICS COVERED/WEEKLY AGENDA

Optimization

- Polyhedra
  - H- and V- representation
  - Function defined on Polyhedra
  - Basic Operations on Polytopes
  - Minkowsky sum, Pontriagin difference and their application to composition with linear function.
- Multiparametric Programming
  - Main idea.
  - Main Concept of Critical Region.
  - Solutions properties of mpLP and of mpQP

Controllability, reachability and invariance

- Controllable and Reachable Sets
- Computation of Controllable and Reachable Sets
- Invariant Sets
- Robust Controllable and Reachable Sets
- Robust Invariant Set

Model Predictive Control

- Definition, Notation and Basic Algorithm.
- Feasibility issue: Problems and Solutions. Persistent feasibility and Persistent feasibility for all feasible inputs. Methods for guaranteeing persistent feasibility.
- Main Theorem of RHC (Stability and Feasibility): proof
- Tuning and Practical Rules
- Zero steady-state tracking RHC
- Online and Offline RHC implementations

Robust model Predictive Control

- Main definition
- Uncertain linear systems with additive and parametric uncertainty

- Choice of Cost, Constraints and Open loop vs Closed Loop predictions
- Difference between Batch approach (also called with open-loop predictions) and Recursive approach (also called with closed-loop predictions)
- Robustification of constraints
- Robust MPC stability and feasibility theorem

Stochastic Model Predictive Control
- Definition, Notation and Basic Algorithm.
- Chance Constraints
- Sampling based methods

Learning Model Predictive Control
- Definition, Notation and Basic Algorithm.
- Sampled Safe Set
- Model learning

Hybrid Systems
- Main idea
- PWA systems
- DHA systems
- MLD systems
- Basic results on optimal control for hybrid systems (MILP/MIQP or explicit solution)

PERSON(S) WHO PREPARED THIS DESCRIPTION

Francesco Borrelli
9/27/17

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): PREDICTIVE CNTRL
TIE CODE: LECS
GRADING: Letter
SEMESTER OFFERED: Fall and Spring
COURSES THAT WILL RESTRICT CREDIT: None
INSTRUCTORS: Packard
DURATION OF COURSE: 15 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 8
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None