University Of California, Berkeley
Department of Mechanical Engineering

ME 230B – Advanced System Theory: Control-Oriented Robustness Analysis (1 Unit)

Graduate Course

Syllabus

CATALOG DESCRIPTION

Theoretical development of the common methods in control system robustness analysis, including general dissipative systems and supply rates, structured singular value, and integral quadratic constraints. Transforming theory into pragmatic algorithms. Use cases in industrial examples.

COURSE PREREQUISITES

Basic graduate background in linear algebra and linear differential equations (ME C232 or EECS 221A or equivalent)

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 quickly expand their knowledge on robustness analysis comprising one part of a complete validation process for complex feedback systems. Students will learn about theory, algorithms, applications and existing software.

DESIRED COURSE OUTCOMES

Students will gain a deep understanding of the modeling assumptions and precise results offered by current state-of-the-art robustness analysis techniques. The wide applicability as well as the limitations of the techniques will be emphasized. The course concludes with a self-directed project, covering a theoretical, algorithmic or applications-oriented issue of interest to each individual student.

TOPICS COVERED

Lp spaces, convolution, Fourier transforms, Parseval theorem, induced norms; Linear dissipative systems; supply rates, storage functions, frequency-domain inequality, linear matrix inequality, general KYP lemma; General dissipative systems and robustness theorems based on supply-rates; structured singular value ("mu"-analysis) computational algorithms; frequency-domain and time-domain derivation of robustness theorems with integral quadratic constraint models, including local and global results; analysis of uncertain systems on finite-horizons. Nonlinear generalizations, including computational certification via sum-of-squares polynomial optimization

CLASS/LABORATORY SCHEDULE

2 hour lecture/week, weeks #1-12; 4-5 hour homework/week, weeks #1-10; 1 hour project work/week, weeks #6-10; 8 hour project work/week, weeks #11-12; project presentations 2 hour/week, weeks #13-15; 2 hour final exam during scheduled final exam period. Approximately 100 hour workload

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

Robustness analysis of complex feedback systems, using dissipative system theory, structured singular value and integral quadratic constraints is ubiquitous in large industrial organizations producing complex engineered systems. Decision makers rely on these tools in order to make informed decisions about the safety, reliability and resilience of a wide variety of systems. It is imperative that advanced students learn both the foundation and application of these modeling and analysis tools, in order to use and interpret them properly, and to extend and improve the tools in the future.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

50% Homework
20% Final Exam
30% Self-directed Project

TOPICS COVERED/WEEKLY AGENDA

1. Lp spaces, convolution, Fourier transforms, Parseval's, induced norms, Sum-of-Squares for polynomial optimization
2. Linear dissipative systems: supply rates, storage functions, quadratic optimization, frequency-domain inequality (FDI), linear matrix inequality (LMI), general KYP lemma
3. General dissipative systems; Robustness theorems using storage functions and supply-rates
4. Structured singular value, definition and basic properties, robustness theorems, computational algorithms
5. Robustness theorems with integral quadratic constraint (IQC) models, including frequency-domain and state-space formulations; library of IQCs for specific linear and nonlinear operators. Analysis with IQCs that are valid only locally
6. Finite-horizon, uncertain linear time-varying (LTV) systems
7. Robustness analysis of nonlinear systems with polynomial vector fields

PERSON(S) WHO PREPARED THIS DESCRIPTION

Andrew Packard
10/20/17

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): CONT ROB ANALYSIS
TIE CODE: LECS
GRADING: Letter
SEMESTER OFFERED: Fall and/or 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: 4
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None