Design Methods for Control Systems

lecturers

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objective

The course presents "classical," "modern" and "postmodern" notions about linear control system design. First the basic principles, potentials, advantages, pitfalls and limitations of feedback control are presented. An effort is made to explain the fundamental design aspects of stability, performance and robustness. Next, various well-known classical single-loop control system design methods, including Quantitative Feedback Theory, are reviewed and their strengths and weaknesses are analyzed. The course includes a survey of design aspects that are characteristic for multivariable systems, such as interaction, decoupling and input-output pairing. Further LQ, LQG and some of their extensions are reviewed. Their potential for single- and multi-loop design is examined. After a thorough presentation of structured and unstructured uncertainty, model design methods based on H-infinity-optimization (in particular, the mixed sensitivity problem and McFarlane-Glover's loopshaping problem) and mu-synthesis are presented.

contents

1. INTRODUCTION TO FEEDBACK THEORY.
   Basic feedback theory, closed-loop stability,
   stability robustness, loop shaping, limits of performance.
2. CLASSICAL CONTROL SYSTEM DESIGN.
   Design goals and classical performance criteria, integral control,
   frequency response analysis, compensator design, classical methods
   for compensator design. Quantitative Feedback Theory.
3. MULTIVARIABLE CONTROL.
   Multivariable poles and zeros, interaction, interaction measures,
   decoupling, input-output pairing, servo compensators.
4. LQ, LQG AND CONTROL SYSTEM DESIGN.
   LQ basic theory, some extensions of LQ theory, design by LQ theory,
   LQG basic theory, asymptotic analysis, design by LQG theory,
   optimization, examples and applications.
5. UNCERTAINTY MODELS AND ROBUSTNESS.
   Parametric robustness analysis, the basic perturbation model,
   the small-gain theorem, stability robustness of the basic perturbation
   model, stability robustness of feedback systems, numerator-denominator
   perturbations, structured singular value robustness analysis, combined
   performance and stability robustness.
6. H-INFINITY OPTIMIZATION AND MU-SYNTHESIS.
   The mixed sensitivity problem, loop shaping, the standard H-infinity
   control problem, state space solution, optimal and suboptimal solutions,
   integral control and HF roll-off, mu-synthesis, application of
   mu-synthesis.

A. Appendix on Matrices
B. Appendix on norms of signals and systems.

course materials

A full set of lecture notes will be made available on the DISC course platform.

prerequisites

Basic undergraduate courses in systems and control. Some familiarity with MATLAB is helpful for doing the homework exercises.

homework assignments

Four homework sets will be distributed via the course website. Homework is graded on a scale from 1 to 10. Missing sets receive the grade 1. The final grade for the course is the average of the grades for the four homework sets.