adaptive control

lecturers

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objectives

Adaptive control covers a set of techniques which provide a systematic approach for automatic adjustment of the controllers in real time, in order to achieve or to maintain a desired level of performance of the control system when the parameters of the plant dynamic model are unknown and/or change in time.

While the design of a conventional feedback control system is oriented firstly toward the elimination of the effect of disturbances upon the controlled variables, the design of adaptive control systems is oriented firstly toward the elimination of the effect of parameter disturbances upon the performance of the control system. An adaptive control system can be interpreted as a hierarchical system composed of a conventional feedback control and an adaptation loop.

The course presents a basic ground for analysis and design of adaptive control systems: it covers both established adaptive schemes based on continuous adaptation, and more recent logic-based adaptive schemes with discontinuous adaptation. The course is organized as follows: after an initiation to parameter adaptation algorithms, Model Reference Adaptive Control (MRAC) schemes constitute the core of the adaptive schemes. MRAC is addressed both from a continuous adaptation point of view and in discontinuous environments, with emphasis on networked environments (switched dynamics and quantization phenomena). The final part of the course is constituted by Adaptive Switching Control (ASC) schemes, which have emerged as an alternative to conventional continuous adaptation. ASC schemes embody a supervisory logic that performs adaptation tasks based on plant input/output data. Different families of logic-based adaptive control schemes will be introduced, including multiple-model ASC schemes, which offer, among other properties, the possibility to combine features from robust and conventional adaptive control.

At the end of the course the student should be able to:
-Design, simulate, and implement parameter adaptation schemes;
-Design, simulate, and implement adaptive control schemes;
-Master the main analytical details in stability and convergence proofs of adaptive control schemes;
-Compare different adaptive control methodologies;
-Discuss simulation results.

contents

Lecture 1 - Introduction and parameter adaptation
- Introduction to adaptive control
- Linear parametric models
- Gradient and least square algorithms
- Robust parameter adaptation laws (elements)

Lecture 2 - Model Reference Adaptive Control (MRAC)
- Model Reference Control with known parameters
- Direct/Indirect MRAC schemes
- Instability examples
- Robust MRAC schemes (elements)

Lecture 3 - Adaptive networked control
- Introduction to hybrid and switched systems (elements)
- Adaptive control of switched systems
- Adaptive quantized control

Lecture 4 - Adaptive Switching Control (ASC)
- Introduction to ASC
- Logic-based supervisors
- Multi-Model ASC

course material

1. Landau I. D., Lozano R., M'Saad M., and Karimi A., Adaptive Control: Algorithms, Analysis and Applications, 2nd edition, Springer-Verlag, 2011.
2. Ioannou P. A. and Fidan B., Adaptive Control Tutorial, SIAM, 2006.

Additional material distributed during the course.

prerequisites

Notions of linear systems theory and Lyapunov stability at the intermediate level. Notions of hybrid systems might turn out useful as well. Extra course material on these topics will be provided to take into account different entry levels. Intermediate MATLAB programming skills are also required.

homework assignments

Two homework assignments, each one accounting for 50% of the final grade. The homework assignments, distributed at the end of the second and the fourth lecture, will consist of both mathematical and programming problem solving exercises.