System Identification, CDS 270

Spring 2012, Caltech

Instructor

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Office Hours: Fridays, by appointment

Grading

Pass / Fail or Grade (extra work will be required)

Prerequisites

Linear systems and control, basic understanding of nonlinear dynamics, Lyapunov stability theory, numerical methods, MATLAB.

Course Outline

The main goal of the course is to give a self-contained mathematical treatment of System Identification (ID) theory and methods. Throughout the course both off-line and on-line system ID methods will be presented. Effectiveness of the design methodology will be demonstrated using static maps and dynamic systems, in continuous and discrete time domains. Students will be asked to run a course project (system ID related) using models of their choice.

Project:

The course project will consist of design, analysis, and simulation of system identification methods for a nonlinear dynamical system. Course projects will be assigned no later than the 4th week of classes from a list of available topics. Project reports will consist of both written and oral portions. The written portion of the report should be a detailed description of the selected topic using the terminology and notation of the class. Reports are due the first day of finals week. Students will present their work in class, during the last week of the term.

Grading Policy: Pass (score 85% or higher) / Fail (otherwise)

a) Class attendance …………………………... 10 %
b) Project report ………………………….. 60 %
c) Oral presentation of project results ………. 20 %

Course material

1. Introduction: Basic approaches to System ID, off-line and on-line parameter estimators, state prediction, adaptive observers, motivating examples.
2. Review of Lyapunov Stability Theory.
3. State-space models. Linear-in-parameters estimation.
4. Gradient and normalized gradient estimation algorithms.
5. Least-squares and modified least-squares algorithms. Parameter estimation methods using exponential forgetting and Projection Operator.
6. Identification of dynamical systems.

7. Adaptive predictors and state observers.
8. Parameter convergence, and Persistency of Excitation (PE) conditions.

Main Textbook

1. P.A. Ioannou & B. Fidan, Adaptive Control Tutorial, SIAM, 2006.

Recommended Books

2. J.J. Slotine, W. Li, Applied Nonlinear Control, Prentice Hall, 1995.
1. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems, Dover, 2005.
2. S. Sastry and M. Bodson, Adaptive Control: Stability, Convergence, and Robustness, Prentice-Hall, 1989, electronic copy available in PDF form at: http://www.ece.utah.edu/~bodson/acscr
3. H.K. Khalil, Nonlinear Systems, 3rd Edition, Prentice Hall, New Jersey, 2002.
4. G.C. Goodwin and K.S. Sin, Adaptive Filtering, Prediction, and Control, Prentice-Hall, 1984.